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THE EAST AFRICAN AGRICULTURAL JOURNAL

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UGANDA AND
ZANZIBAR

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NOTES ON KENYA AGRICULTURE—VII

NOTES ON ANIMAL DISEASES: REDWATER AND ANAPLASMOSIS

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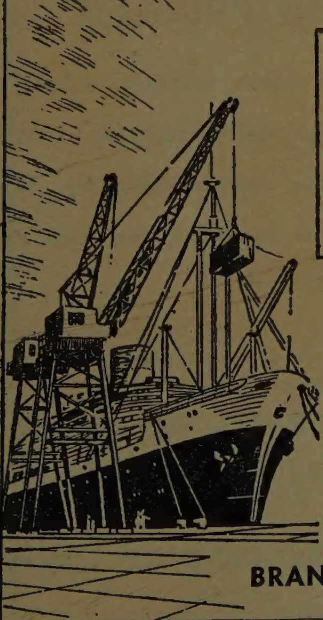

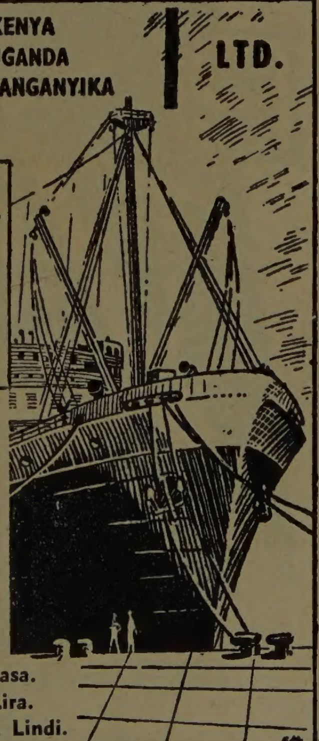

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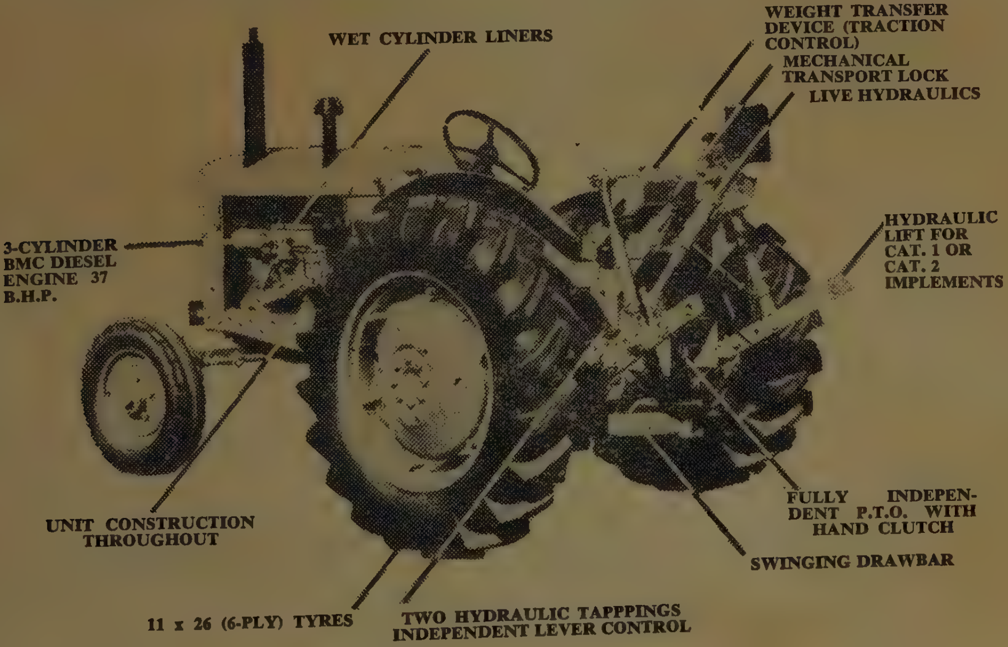
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THE

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Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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TYPING

Papers should be typed on thick foolscap paper, double-spaced, with wide margins. Only the ribbon copy need be submitted.

TITLE

The title should be brief but self-explanatory, suitable for indexing. Place-names should be followed by the name of the country, e.g. Makueni, Kenya. The author's address should be sufficient to enable a reader to write to him: usually the departmental address is most suitable. Decorations and degrees are not published after the author's name.

TEXT

If possible, the paper, including tables and illustrations, should not occupy more than five pages of print, i.e. 4,500 words, or 15 foolscap pages of double-spaced typing. Papers longer than this will probably be returned for revision, since they are almost certain to contain unnecessary detail.

ILLUSTRATIONS

Line drawings are usually reproduced in column width, i.e. 2⅝ inches, and thus a convenient width for original drawings is three times column width, approximately the width of a foolscap page. Larger drawings, such as maps, may be reproduced as full-page blocks, i.e. 5½ × 8 inches, but it is often possible to reduce these to half-page size by omitting areas which are irrelevant to the text. Letters and numbers should be inserted with lettering guides, the sizes being suitable for reduction to block size. Lines, etc., should be drawn in Indian ink, ensuring that they are all jet black.

Photographs should preferably be half-plate size, with very good detail, printed on glossy contrasty paper. They should preferably be taken upright ("portrait" style as compared with "landscape") so that they can be reproduced in column width. All unnecessary background should be trimmed off, or the part to be reproduced should be demarcated by light pencil lines (preferably blue) on the back of the print. The plate number should be written on a corner on the back with blue pencil, but the caption should never be written or typed on the back; it should be given on a separate sheet.

TABLES

The number and size of tables must be cut to the absolute minimum, and a maximum of five compact tables should be sufficient for the presentation of experimental evidence. Only positive results should be included, since negative or inconclusive observations can be summarized in the text, and a reader who wishes further details can write to the author for them.

SUMMARY

The summary should not be longer than three per cent of the text, and it should be suitable for abstract journals.

REFERENCES

References in the text should either be by number or, preferably, by author's names and date, e.g. Smith *et al* 1954. Numbered referencces are listed at the end of the paper in numerical order, while author references are listed in alphabetical order. Abbreviations should conform to the World List of Scientific Periodicals: most abbreviations can be found in the reference section of previous papers in this journal.

The following papers give most useful advice on the presentation of technical papers:—

Price, W. C. (1954). Preparing manuscript for Phytopathology. *Phytopathology 44*, 675.

Moreau, R. E. (1947). On writing for this Journal. *E. Afr. agric. J. 12*, 171.

Riker, A. J. (1946). The preparation of manuscripts for Phytopathology. *Phytopathology 36*, 953.

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D. W. D.

THE EAST AFRICAN AGRICULTURAL JOURNAL

RETIREMENT OF DR. D. W. DUTHIE EDITOR, 1945-59

With this number of the Journal Mr. J. Glover takes over the editorship from Dr. D. W. Duthie, who is retiring after 28 years' active work in the Colonial territories, of which the last 15 have been spent in East Africa, at first with the old East African Agricultural Research Institute, Amani, and then with its successor the East African Agriculture and Forestry Research Organization. Dr. Duthie became Assistant Editor in April, 1945, and took over the full duties of Editor in 1947, a duty which he has performed continuously since then, except for the periods of his overseas leaves.

During these 14 years, Dr. Duthie has more than maintained the high standard of the presentation of papers on scientific agriculture and related subjects which the Journal has enjoyed from its inception. In addition he has established a remarkable reputation for giving help to relatively inexperienced contributors who were submitting papers for the first time, and he has spent many hours in the evenings advising them how best to present their material and has often been able to show the authors that further conclusions which they themselves had not spotted could be drawn from their results. He could only do this through his wide knowledge of agriculture and by possessing a patience with contributors which editors sometimes lack.

The Editorial Board wish to take this opportunity of thanking Dr. Duthie for all this work which he put into the Journal, to help it reach its present very high internal and international reputation. They send him their best wishes on his departure from East Africa. The Board also wish to take this opportunity of welcoming Mr. Glover as the new Editor. He started working in East Africa as a plant physiologist in the East African Agricultural Research Institute, in 1937, and transferred to E.A.A.F.R.O. in 1948. He also has been able to acquire a wide knowledge of East African agricultural problems, and the board are very grateful to him for undertaking this additional duty.

NOTES ON KENYA AGRICULTURE

VII.—INSECT PESTS AND CONTROL MEASURES

By J. F. Graham, Department of Agriculture, Kenya

(With notes on the control of storage pests by S. P. L. Kockum, Department of Maize and Produce Control, Kenya)

Specimens for Identification

Twenty to thirty specimens are needed for the identification of a species being recorded for the first time. Specimens of damage are also useful, as damage caused by certain pests is characteristic. Specimens should be sent in cardboard boxes (e.g. 50-cigarette boxes) packed in paper. Avoid tins and packing with leaves; these result in humid conditions, putrefaction and growth of moulds. Beetles may be killed by dropping them into hot water. Immature insects such as caterpillars or beetle grubs are best sent alive, as rearing to the adult, which may be identified, is sometimes possible. Address specimens to officers and not individuals by name; specimens for identification in Nairobi should be addressed to the Senior Entomologist, Scott Agricultural Laboratories, P.O. Box 30028, Nairobi.

Precautions in the Use of Poisonous Substances in Agriculture

With all insecticides care should be taken, since very few are completely innocuous to man. Usually the simple precautions of spraying down-wind so as not to breathe appreciable quantities of the spray, washing off concentrates that may spill on the skin, and washing well after spraying is over are all that is needed.

This is satisfactory for ordinary dilutions of aldrin, BHC, chlordane, chlorobenzilate, Diazinon, DDT, derris, dieldrin, malathion and pyrethrum for example. With more toxic sprays e.g. parathion, methyl parathion, systox and endrin a faceshield, a washable overall and rubber boots and gloves should be worn. Where tall crops are being sprayed a waterproof coat and hood are needed in addition. Legislation covering the use of such substances should be consulted.

If in doubt refer to the Senior Entomologist, Scott Agricultural Laboratories, P.O. Box 30028, Nairobi, before using sprays which may be dangerous to operators.

Mixing and Diluting Insecticides

Dusts can be diluted with a suitable carrier. Kenya diatomite is the material most readily available in this country but it is often unsuitable, particularly for drift-dusting because of its lightness. In effect, the heavier insecticide particles may fall out of the dust stream near the machine while the lighter diatomite particles carry on without effecting a kill. Heavier dusts can be incorporated by local manufacturers who have special mixing equipment. Where dusts are hand placed, as for stalk borer treatment, the density of the diluent is of no consequence.

Wettable powders can be diluted with suitable carriers to form dusts or with water for use as sprays. The powder should be mixed to a paste with water in the latter case and is gradually brought to a fine suspension by the addition of more water. Cheap wettable powders may consist of coarse particles which eventually settle down. Such materials should be made up in small quantities as required and are best used in machines fitted with agitators.

Emulsifiable concentrates usually present no difficulties if added to a small quantity of water and stirred to give complete mixing.

Emulsifiable concentrates are easier to dilute since only volumes are involved.

In practice, since litre and millilitre measures are not always available, one can work in fluid ounces.

1 gallon = 160 fluid oz.
1 pint = 20 fluid oz.
1 fluid oz. = 2 tablespoons = 4 dessert = 8 teaspoons.
A whisky bottle holds 1/6 gallon or 26.2/3 fluid oz.

A bucket can be calibrated by adding water from a measure and painting lines at $\frac{1}{4}$, $\frac{1}{2}$ and 1 gallon levels. Polythene buckets already marked are available. These have the advantage that they do not dent or rattle.

To make up, say 0.04 per cent endrin from the 19.5 per cent concentrate, the final strength is subtracted from the original,

i.e. 19.5 − 0.04 = 19.46.

From the latter figure find the number of parts represented by the final dilution,

i.e. 0.04 to 19.46

or 1 part to 486.5 of diluent.

If only 1½ gallons of spray are required, i.e. 240 fluid ounces, then ½ fluid ounce of concentrate is needed.

To obtain 0.05 per cent from 50 per cent wettable powder the same rule may be applied,

i.e. 50 − 0.05 = 49.95.

5 parts of wettable powder to 4,995 of water or 1 ounce of wettable powder to 999 of water.

Since 1 fluid ounce of water weighs one ounce then 999 fluid ounces or approximately 8¼ gallons are required.

Active Ingredient per acre

Sometimes a recommendation is given in pounds of active ingredient per acre, e.g. 1 lb. of D.D.T. per acre. This means, for example, 2 lb. of 50 per cent wettable powder, 3 lb. of 33⅓ per cent wettable powder or 4 lb. of 25 per cent emulsifiable concentrate. Since 1 oz. of concentrate is approximately 1 fluid oz. in the latter case one would use 64 fluid oz. or approximately three pints per acre. The recommendation could also be met with 10 lb. of 10 per cent D.D.T., 20 lb. of 5 per cent D.D.T., or even 40 lb. of 2½ per cent D.D.T. dust. One per cent D.D.T. entailing 100 lb., would, however, probably be too weak.

The amount of water to be used is not stated for wettable powder and emulsifiable concentrates. This is left to the discretion of the user. Thus 2 lb. of 50 per cent wettable powder might be applied in 50 gallons from a boom sprayer but perhaps in 100 gallons from knapsacks. The concentrates might be applied in as little as 10 gallons of water by a low volume sprayer or, again, in 100 gallons in knapsacks.

Further information on insecticides and the strengths of proprietary brands which are obtainable in East Africa may be obtained in a very useful article which appeared in *East African Agricultural Journal*, October, 1957, Vol. XXIII, page 74. The recommendations given, however, are not always the same as those given in the next section of these notes.

In the Food and Drug (Adulteration) Regulations, 1956, it is laid down that for the purpose of protection from insect or mite infestation only the addition of the following material is allowed; diatomaceous earth, bentonitic clay, kaolin, or chalk in a proportion not exceeding ½ lb. to 200 lb. of grain, flour, or seed. The permissible content of insecticides or miticides in grain, flour, or seed are:—

Pyrethrum powder, 2.500 p.p.m.
Pyrethrins, 25 p.p.m.
Lindane, 1 p.p.m.

TABLE OF DILUTIONS

% Active Ingredient Required	% Active Ingredient in Concentrate												
	6·5	10	15	18	18·5	19·5	20	24·5	25	33·3	40	50	60
1·0	5·5	9	14	17	17·5	18·5	19	23·5	24	32·3	39	49	59
0·5	12	19	29	35	36	38	39	48	49	65·6	79	99	119
0·1	64	99	149	179	184	194	199	244	249	332	399	499	599
0·08	80	124	187	224	230	243	249	305	312	416	499	624	749
0·06	107	166	249	299	308	324	332	408	416	556	666	832	999
0·05	129	199	299	359	369	389	399	489	499	666	799	999	1,199
0·04	162	249	374	449	462	487	499	612	624	832	999	1,249	1,449
0·03	216	332	499	599	616	649	666	816	832	1,110	1,332	1,666	1,999
0·02	324	499	749	899	924	974	999	1,224	1,249	1,666	1,999	2,449	2,999
0·01	649	999	1,499	1,799	1,849	1,949	1,999	2,449	2,499	3;332	3,999	4,999	5,999

For example, to make a spray of 0·05% from a concentrate of 18% read along the row marked 0·05 at the left until the column headed 18% is reached and the figure 359 is found; this is the number of parts of water to be added to 1 part of an 18% concentrate to make a spray of 0·05% strength.

The insecticide manufacturers in Kenya have agreed to mark all 0.04 per cent gamma B.H.C. packings with a Maltese Blue Cross, showing that this insecticide when properly used is safe. Further, all 0.5 per cent (½ per cent) gamma B.H.C. packings are marked with a red triangle, a warning signal that this insecticide may not be directly admixed with food or grain except with cob maize, in which case it is subsequently removed by shelling.

SOME OF THE MORE IMPORTANT PESTS

Information given under the following heads:—

(1) = English name.
(2) = Scientific name.
(3) = Crop attacked.
(4) = Part of plant attacked.
(5) = Area infested.
(6) = Status as pest.
(7) = Control measures used.

I. ORTHOPTERA.—Grasshoppers, crickets, cockroaches. All stages harmful.

1. (1) Desert locust. (2) *Schistocerca gregaria.* (3) Graminae. (4) Foliage. (5) All areas. (6) Major. (7) Controlled by special organizations.
2. (1) Migratory locust. (2) *Locusta migratoria.* (3) Many. (4) Foliage. (5) All areas. (6) Major. (7) Controlled by special organizations.
3. (1) Red locust. (2) *Nomadacris septemfasciata.* (3) Graminae. (4) Foliage. (5) All areas. (6) Rarely present. (7) Controlled by special organizations.
4. (1) Grasshoppers. (2) *Gastrimargus, Cataloipus,* etc. (3) Graminae. (4) Foliage. (5) Rift Valley. (6) Sometimes severe. (7) Bait with bran containing 2½ per cent of B.H.C. of 2.5 to 3 per cent gamma. Spray with Diazinon or Malathion on food crops (0.1 per cent).
5. (1) Grasshopper. (2) *Homorocoryphus vicinus.* (3) Rice and other cereals. (4) Leaf and seed heads. (5) Coast. (6) Occasionally severe. (7) Control as for No. 4.
6. (1) Crickets. (2) *Brachytrypes membranaceus.* (3) Garden plants. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) Control as for No. 4.

II. ISOPTERA.—Termites. All stages harmful.

7. (1) Termites. (2) *Pseudacanthotermes militaris.* (3) Sugar cane. (4) Roots and stem. (5) Nyanza. (6) Severe. (7) Prevent damage by dipping setts in Dieldrin 0.1 per cent solution.
8. (1) Termites. (2) *Termes* spp. and other genera. (3) Sometimes on living plants. (4) Wood. (5) All areas. (6) Important. (7) Pour Aldrin or Dieldrin emulsion into nests—1 fluid oz. to two or more gallons of water. Spray attacked areas with the above dilution.

III. THYSANOPTERA.—Thrips. All stages harmful.

9. (1) Thrips. (2) *Diarthrothrips coffeae.* (3) Coffee. (4) Foliage. (5) All areas. (6) Major. (7) Two or more sprayings with 0.1 per cent Diazinon or Malathion. In serious infestation use 0.1 per cent D.D.T. spray.
10. (1) Thrips. (2) *Thrips tabaci.* (3) Onion, Pyrethrum. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) D.D.T. 25 per cent emulsion, three pints/acre. Spray two or three times.

IV. HEMIPTERA.—Bugs, stainers, aphids, scales, mealybugs. All stages harmful.

11. (1) Antestia. (2) *Antestiopsis* sp. (3) Coffee. (4) Fruit, branches. (5) All coffee areas. (6) Major. (7) Pyrethrum dust 10-12 lb. per acre, Malathion 50 per cent, 1 fluid oz. to two gallons water.
12. (1) Green stink bug. (2) *Nezara viridula.* (3) Legumes, cotton. (4) Foliage. (5) All areas. (6) Minor. (7) Three pints 25 per cent D.D.T. emulsion per acre or one pint 18 per cent Dieldrin.
13. (1) None. (2) *Bagrada picta.* (3) Vegetables, cereals. (4) Foliage. (5) All areas. (6) Minor. (7) Control as for No. 12.
14. (1) Coconut Coreid bug. (2) *Pseudotheraptus wayi.* (3) Coconut. (4) Flowers. (5) Coastal areas. (6) Major. (7) D.D.T. or Dieldrin sprays with Coumarone resin where necessary.
15. (1) Stainers. (2) *Dysdercus* spp. (3) Cotton. (4) Bolls. (5) All cotton areas. (6) Major. (7) 3.10.0. Cotton dust. Spray three pints 25 per cent D.D.T. emulsion or 1½ pints Gammalin 20/acre.
16. (1) Capsid bug. (2) *Lygus coffeae.* (3) Coffee. (4) Flower buds. (5) All areas. (6) Occasionally major. (7) Pyrethrum dust, Malathion 50 per cent 1 fluid oz. to two gallons water.

17. (1) Cotton lygus. (2) *Lygus vosseleri.* (3) Cotton, sorghum. (4) Foliage. (5) Nyanza, Coast. (6) Major. (7) Three pints of 25 per cent D.D.T. emulsion or 5 per cent D.D.T. dust.

18. (1) Jassid. (2) *Empoasca* spp. (3) Cotton. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) Three pints 25 per cent D.D.T./acre, Diazinon 0.1 per cent spray.

19. (1) Cotton aphis. (2) *Aphis gossypii.* (3) Cotton, hibiscus. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) 3 per cent B.H.C. (or 0.5 gamma B.H.C.) dust. Malathion 0.1 per cent (or greater dilution).

20. (1) Mealy aphis. (2) *Brevicoryne brassicae.* (3) *Brassicae.* (4) Foliage. (5) All areas. (6) Sometimes severe. (7) 0.5 per cent gamma B.H.C. dust, Malathion or Diazinon 0.1 per cent (or less) spray.

21. (1) Pea aphis. (2) *Macrosiphum pisi.* (3) Peas. (4) Foliage. (5) All areas. (6) Minor. (7) Malathion or Diazinon 0.1 per cent (or less) spray.

22. (1) Wheat Greenfly. (2) *Schizaphis graminum.* (3) Small grain cereals. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) One pint of Malathion 50 per cent or half pint Diazinon 60 per cent per acre.

23. (1) Mealybug. (2) *Pseudococcus kenyae.* (3) Coffee, (4) Foliage, branches, stems. (5) Central Province. (6) Formerly major, now less. (7) Control by parasites. Band tree trunk with one part of 18 per cent Dieldrin emulsion in 19 parts of water, add 2 oz. methylene blue to each 10 gallons as a marker.

24. (1) Pineapple mealybug. (2) *Dysmicoccus brevipes.* (3) Pineapples. (4) Roots, foliage, fruit. (5) All areas. (6) Major. (7) Plant clean material fumigated or dipped in Diazinon 0.05 per cent or Malathion 0.1 per cent. Control ants by Dieldrin emulsion or dust. Spray foliage with Malathion 0.1 per cent to reduce infestation.

25. (1) Jacaranda Bug. (2) *Orthezia insignis.* (3) Garden plants. (4) Foliage and branches. (5) Part of Central Province and part of Nyanza. (6) Severe. (7) Control by predatory ladybirds. Spray 0.1 per cent Diazinon.

26. (1) Cottony Cushion Scale. (2) *Pericerya purchasi.* (3) Ornamental plants. (4) Foliage. (5) All areas. (6) Minor. (7) Diazinon 0.1 per cent spray. Repeat 14 days later.

27. (1) Green Scale. (2) *Coccus africanus.* (3) Coffee. (4) Foliage, branches. (5) All coffee areas. (6) Sometimes severe. (7) 2 to 3 per cent Alboleum. Diazinon or Malathion 0.1 per cent spray. On trees band trunk as for coffee mealybug.

28. (1) Scale. (2) *Diaspis bromeliae.* (3) Pineapple. (4) Foliage, fruit. (5) Several areas. (6) Sometimes severe. (7) Diazinon 0.1 per cent or Malathion 0.1 per cent spray.

29. (1) Cassava Scale. (2) *Aonidomytilus albus.* (3) Cassava. (4) Stems and leaves. (5) All areas. (6) Sometimes severe. (7) As for No. 28.

30. (1) Red Scale. (2) *Aonidiella aurantii.* (3) Citrus. (4) Foliage and branches, fruit. (5) All areas. (6) Sometimes severe. (7) As for No. 28.

V. LEPIDOPTERA.—Moths and butterflies. Larva harmful.

31. (1) Pink bollworm. (2) *Platyedra gossypiella.* (3) Cotton. (4) Boll. (5) Coast, North Nyanza. (6) Minor. (7) 3.10.0. Cotton dust at weekly intervals. Crop hygiene, plant clean seed.

32. (1) Sweet potato butterfly. (2) *Acraea acerata.* (3) Sweet potato. (4) Foliage. (5) Parts of Nyanza. (6) Sometimes severe. (7) 0.1 per cent D.D.T. spray. Endrin E.C. 1 fluid oz. in five gallons.

33. (1) Wattle caterpillar. (2) *Argyrostagma niobe.* (3) Wattle. (4) Leaf and shoot. (5) All areas. (6) Sometimes major. (7) One pint of Endrin E.C. in two gallons Dieselene per acre.

34. (1) Angoumois grain moth. (2) *Sitotroga cerealella.* (3) Maize. (4) Stored grain. (5) All areas. (6) Major. (7) Crib dust of 0.5 per cent gamma B.H.C. to every 9 cu. ft. of cobs.

35. (1) False codling moth. (2) *Argyroploce leucotreta.* (3) Cotton, citrus, peach, etc. (4) Fruit. (5) All areas. (6) Sometimes severe. (7) Orchard hygiene. Destroy all fallen fruit every three days by deep burying. Apply persistent insecticide under trees. Lure moths with baits. Insecticide controls not very effective.

36. (1) Leaf Miner. (2) *Leucoptera* spp. (3) Coffee. (4) Foliage. (5) All coffee areas. (6) Sometimes severe. (7) Spray Diazinon 60 per cent, one part in 640 of water. Malathion effective against adults.

37. (1) Diamond Back moth. (2) *Plutella maculipennis*. (3) Cruciferae. (4) Foliage (5) All areas. (6) Sometimes severe. (7) Spray D.D.T. three pints of 25 per cent emulsion per acre. Dust with pyrethrum. Spray 0.1 per cent Diazinon, not in last week before harvesting.

38. (1) Cutworms. (2) *Agrotis segetum*, etc. (3) Maize, vegetables, coffee, etc. (4) Roots and stem. (5) All areas. (6) Sometimes severe. (7) Seed dressings of Aldrin plus shallow planting. Spray soil with Aldrin, bait with bran containing 4 per cent of 2.6 per cent gamma B.H.C.

39. (1) Army worm. (2) *Laphygma exempta*. (3) Grass, maize, etc. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) 1 lb. D.D.T. per acre.

40. (1) Flax caterpillar. (2) *Plusia orichalcea*. (3) Flax. (4) Foliage and seed. (5) All flax areas. (6) Sometimes severe. (7) 1 lb. D.D.T. per acre.

41. (1) Tomato worm. (2) *Heliothis armigera*. (3) Tomato, maize, cotton, etc. (4) Foliage, fruit. (5) All areas. (6) Sometimes severe. (7) 1 lb. D.D.T. per acre at intervals of seven to ten days.

42. (1) Stalk Borer. (2) *Busseola fusca*, etc. (3) Maize. (4) Stem and cob. (5) All areas. (6) Major. (7) 1 per cent D.D.T. dust as hand dressing.

43. (1) None. (2) *Epicampoptera andersoni*. (3) Coffee. (4) Foliage. (5) Nyanza Province. (6) Sometimes severe. (7) 0.1 per cent D.D.T. spray or 30 lb. 5 per cent D.D.T. dust per acre; 5-10 lb. pyrethrum powder per acre, 2 lb. lead arsenate/100 gallons of water; or 1 lb. Paris Green/5 lb. hydrated lime in 200 gallons of water.

VI. COLEOPTERA.—Beetles, chafers, weevils. Adults and grubs harmful.

44. (1) Rhinoceros beetle. (2) *Oryctes monoceros*. (3) Coconut. (4) Foliage. (5) Coastal areas. (6) Major. (7) Traps of compost heaps. Remove grubs at regular intervals. Plantation hygiene—removal of dead trees and branches.

45. (1) Black wheat beetle. (2) *Heteronychus* spp. (3) Wheat, barley, etc. (4) Roots, stems. (5) Ol Kalou, Lumbwa, etc. (6) Major (adults). (7) Seed dressings of gamma B.H.C., Aldrin and, perhaps, Dieldrin, 1 oz. to 20 lb. of seed of Mergamma "A" or Aldrin 40 per cent.

46. (1) Chafer grub. (2) *Schizonycha* spp. (3) Maize, wheat, flax, etc. (4) Roots. (5) Trans Nzoia, Uasin Gishu. (6) Minor (grubs). (7) Seed dressings of Aldrin give some protection. In heavy infestations apply 2½ lb. of 40 per cent Aldrin per acre.

47. (1) June beetle. (2) *Popillia* spp. (3) Fruit, garden plants. (4) Fruit (adults), roots (larvae). (5) All areas. (6) Minor. (7) Dust adults with 5 per cent D.D.T. Seed dressings and soil treatments as for No. 46.

48. (1) Dusty Brown beetle. (2) *Dasus simplex*. (3) Maize, wheat, coffee, etc. (4) Roots and stems. (5) All areas. (6) Major. (7) Adults—bait of 2½ parts of 2.6 per cent gamma B.H.C. in 100 parts bran. Adults and grubs—seed dressings of gamma B.H.C. or Aldrin.

49. (1) None. (2) *Mylabris* spp. (3) Legumes (4) Foliage. (5) All areas. (6) Minor (adults). (7) Dust 5 per cent D.D.T. or spray 1 lb. of D.D.T. per acre.

50. (1) White Borer. (2) *Anthores leuconotus*. (3) Coffee. (4) Stems. (5) Makuyu, etc. (6) Major. (7) Band stems with Dieldrin 1 in 19 plus 2 oz. Methylene Blue to each 10 gallons. Three successive bandings may be needed.

51. (1) Bean beetle. (2) *Bruchus* spp. (3) Beans. (4) Seed. (5) All areas. (6) Sometimes severe, damage to stored beans. (7) Dust beans with ½ lb. of 0.04 per cent gamma B.H.C. to each 200 lb. of beans.

52. (1) Ladybirds. (2) *Epilachna* spp. (3) Maize, grass, potatoes, etc. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) 5 per cent D.D.T. dust or 1 lb. of D.D.T. (sprayed) per acre.

53. (1) Weevil. (2) *Alcidodes* spp. (3) Sweet potato. (4) Stems and tubers. (5) Central Province. (6) Sometimes severe. (7) Dusts of 2½ or 5 per cent D.D.T., 0.5 per cent gamma B.H.C. or 0.5 per cent Dieldrin or 1.25 per cent Aldrin probably effective.

54. (1) Banana weevil. (2) *Cosmopolites sordidus*. (3) Banana. (4) Stems. (5) Parts of Nyanza and Coast. (6) Major. (7) Spray 0.1 or 0.2 Dieldrin. Dust 0.5 per cent Dieldrin or 1.25 per cent Aldrin.

55. (1) Maize weevil. (2) *Calandra oryzae*. (3) Maize, stored products. (4) Seed. (5) All areas. (6) Major. (7) Dust cobs with 0.5 gamma dust, ½ lb. to 9 cu. ft.

56. (1) Sisal weevil. (2) *Scyphophorus acupunctatus*. (3) Sisal. (4) Foliage and stem. (5) Coast Province. (6) Severe. (7) 1.25 per cent Aldrin dust when planting. Practice plantation hygiene and remove old poled plants.

57. (1) Weevil. (2) *Nematocerus* spp. (3) Maize, wattle, wheat, tea. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) Baits of 2½ per cent by weight of 2.6 per cent gamma B.H.C. with chopped maize bran or maizemeal. Spray foliage with 0.1 per cent B.H.C. Dust with 2.6 per cent gama B.H.C. Heavy applications of soil insecticide for larvae which damage roots.

58. (1) Snout beetle. (2) *Gonipterus scutellatus*. (3) Eucalyptus. (4) Leaves. (5) All areas. (6) Occasionally severe. (7) Normally controlled by parasites.

59. (1) Sweet potato weevil. (2) *Cylas puncticollis*. (3) Sweet potato. (4) Tubers. (5) All areas. (6) Sometimes severe. (7) Plant clean material. Sort out infested potatoes and feed to stock. Store in building dusted with 10 per cent D.D.T.

VII. Hymenoptera.—Ants, borer bees and wasps, sawflies.

60. (1) Harvester ant. (2) *Messor* sp. (3) Grasses. (4) Flowers and seeds. (5) Grassland, plains. (6) Appreciable damage. (7) Bait of one part of 40 per cent Aldrin to 32 of maizemeal down and around entrance holes.

61. (1) Ant. (2) *Pheidole megacephala*. (3) Attending scale insects. (4) Scales on all parts. (5) All areas. (6) Injurious insect through effect on Coccids. (7) On trees band with one part of 18 per cent Dieldrin emulsion in 19 of water. Elsewhere spray one part Dieldrin in 150 of water.

62. (1) Sawflies. (2) *Athalia* spp. (3) Brassicae. (4) Foliage. (5) All areas. (6) Sometimes severe (larvae). (7) Dust of 2½ per cent D.D.T. or spray 1 lb. D.D.T. per acre. On food crops use derris or pyrethrum.

VIII. Diptera.—Leatherjackets, fruit flies, shoot borers, midges. Grubs harmful.

63. (1) Barley bulb fly. (2) *Hylemyia arambourgi*. (3) Barley, wheat. (4) Seedling. (5) All areas. (6) Sometimes severe. (7) Seed dressings of 40 per cent Aldrin wettable powder, 12 oz./100 lb. of seed or 50 per cent Dieldrin wettable powder 10 oz./100 lb. of seed.

64. (1) Central shoot fly. (2) *Atherigona indica*. (3) Sorghum. (4) Shoot. (5) All areas. (6) Sometimes severe. (7) Dust of 1½ per cent gamma B.H.C./5 per cent D.D.T., every ten days. Spray 0.1 per cent D.D.T.

65. (1) Sorghum midge. (2) *Contarinia sorghicola*. (3) Sorghum. (4) Flowers. (5) Nyanza. (6) Minor. (7) Sprays of D.D.T. or Endrin probably effective.

66. (1) Bean fly. (2) *Melanagromyza phaseoli*. (3) Beans. (4) Leaves and stems. (5) All areas. (6) Sometimes severe. (7) Seed dressings of Aldrin 40 per cent—1 lb to 100 lb. of seed.

67. (1) Fruit fly. (2) *Ceratitis capitata*. (3) Coffee, etc. (4) Fruit. (5) All areas. (6) Sometimes severe. (7) Destroy all infested fruit by deep burying; dust persistent insecticides under fruit trees to kill pupae, bait with Malathion, hydrolysed yeast and sugar in water.

68. (1) Fruit fly. (2) *Ceratitis rosa*. (3) Peach, etc. (4) Fruit. (5) All areas. (6) Sometimes severe. (7) As No. 67.

69. (1) Fruit fly. (2) *Dacus* and *Tridacus* spp. (3) Cucurbitae. (4) Fruit. (5) All areas. (6) Sometimes severe. (7) As No. 67.

IX. Pests which are Not Insects

Acarina—mites.
Diplopoda—millipedes.
Gastropoda—slugs and snails.

70. (1) Red spider mite. (2) *Tetranychidae*—several spp. (3) Citrus, beans, garden plants. (4) Foliage. (5) All areas. (6) Sometimes severe. (7) Use miticide on advice of entomologist.

71. (1) Citrus red spider mite. (2) *Eutetranychus banksi*. (3) Citrus spp. (4) Foliage and fruit. (5) All areas. (6) Severe. (7) As No. 70.

72. (1) Citrus rust mite. (2) *Phyllocoptruta oleivorus*. (3) Citrus spp. (4) Foliage and fruit. (5) All areas. (6) Sometimes severe. (7) Chlorobenzilate 0.03 per cent twice or thrice at fortnightly intervals.

73. (1) Citrus bud mite. (2) *Aceria sheldoni.* (3) Citrus. (4) Leaf, shoot and fruit. (5) All areas (6) Major. (7) Chlorobenzilate 0.03 per cent twice or thrice at fortnightly intervals.

CONTROL OF STORAGE PESTS

General Hygiene

Hygiene is the first essential for controlling granary pests and rodents. The worst of these are insects which already occur in the field and are carried to the stores at harvest time, namely the weevil *Calandra oryzae* and the moth *Sitotroga cerealella*. The field crop becomes infested during the late growing period, chiefly from breeding centres supplied by the stores and their surroundings. Other pests live only in the food products and the refuse in the store.

The key to proper hygiene is in store structure (to be discussed later), but routine cleaning, spraying, etc. are absolute essentials. Store walls and floors must be swept at regular intervals. Dust-collecting cobwebs, sills, corners and ledges must receive special attention. Sweepings must not be left in a bag in the corner of the store. They should be burnt or otherwise destroyed, or mixed with an insecticidal dust. Empty used bags must not be kept in the store proper, and all such empty bags should be treated to render them insect-free. Grain stores should not be used simultaneously as stores for machinery, dunnage, etc. Maize meal and other products highly liable to infestation should not be kept in a grain store; nor should whole grain be stored in the same building in which a mill is used.

The surroundings of the store should also be kept clean. Accumulation of waste grain or feed may be found in nearly every part of the farmstead and should be carefully searched for and removed. These include spillage accumulations made by rodents, seepage of grain through cracks in the floors, grain trapped in double-walled constructions, and piles of uncleaned grain and cob heaps left after shelling. Thorough cleaning necessitates the cutting of weeds from under cribs and around store buildings. All these measures also help to keep away rats.

Fumigation of Buildings

After the store has been scrupulously swept it should be sprayed with an insecticide. Spraying should be repeated every two months. A mixture of 6 oz. of 25 per cent Lindane wettable powder and 6½ oz. of 50 per cent D.D.T. in one gallon of water, applied at the rate of one gallon for 1,000 sq. ft. is adequate.

Moth infestation in storage buildings may be controlled by the regular use of fog-sprays containing pyrethrins (0.35 per cent plus piperonyl butoxide (3.5 per cent). B.H.C. smoke generators have also been claimed to be effective. The store must be well closed for the treatment.

Crib Hygiene

The latter spray should also be used in cribs before they are filled and after they and their surroundings have been thoroughly cleaned.

CRIB STORAGE

Structure

Maize cribs may be circular or rectangular (if the latter, preferably orientated in an east-west direction). The crib should be situated on dry ground. Cribs should not be wider than 8-10 ft. In experiments with cribs 9 ft. wide at Scott Laboratory no difference in protection from insects, nor in drying have been detected relevant to walls made from wire-netting, maize stalks, grass thatch, or hessian-covered wire. Metal roofs should be provided on permanent cribs. The floor should be raised high enough from the ground to permit cleaning underneath. If directly on the ground, as in the Argentine crib, a thick bedding of maize stalks should be laid before bringing in the crop.

Crib Insecticides

The maize cobs should be dusted when being placed in the crib with 0.5 per cent (½ per cent) Lindane in diatomite (Red Triangle) at a rate of ½ lb. per 9 cu. ft. An even distribution throughout the crib is essential. During shelling the insecticide is almost entirely removed.

Recent Advances

A still more effective treatment for maize in cribs has recently been developed at Scott Agricultural Laboratories. The wire-netting walls are first covered with hessian. The cobs are dusted with only ¼ lb per 9 cu. ft. of 0.12 per cent (⅛ per cent) Lindane in diatomite, but after the crib is filled the hessian is sprayed with an insecticidal solution of Lindane (40 g.)

and Coumarone resin (4 g.) in 1 litre of kerosene (applied at the rate of 1 litre per 100 sq. ft. of hessian). This treatment has been found to stop all damage, even that caused on the outer cobs by moth, for a period greater than one year.

BAG AND BULK STORAGE

Simple Bag Treatments

A well-mixed application of 8 oz. of Blue Cross Lindane with grain or legumes in a 200-lb. bag will keep it free from pests for more than one year. Blue Cross is a preparation of 0.04 per cent (1/25th of 1 per cent) Lindane in diatomite. This treatment with wheat seems to affect the bushel weight. A formulation of 0.15 per cent pyrethrins plus 2.4 per cent piperonyl butoxide in pyrethrum marc at a rate of 4 oz. per 200 lb. may be effectively used. There is no need to attempt to remove the small quantities of insecticide before consumption. Grain which has not been mixed with 0.04 per cent Lindane or pyrethrins should be dusted with 0.5 per cent Lindane at a rate of 3 oz. on the surface of each bag in order to reduce cross-infestation.

Fumigation of Bag Stacks

Treatment of stacks of bags, or of bulk grain, for pest control is best done by fumigation. Fumigation under gas-proof sheets with methyl bromide (2 lb. per 1,000 cu. ft. of space, for 48 hours) is most effective. Such a treatment cannot be recommended for general farm use, for the operation involves risks that must be met by trained operators.

Fumigation of Bulk in Bins or Farm Silos

Several fumigants are supplied in the trade. The most common consists of carbon tetrachloride-carbon disulphide, or ethylene dichloride-carbon tetrachloride. These fumigants used in grain fumigation are poisonous to human beings and animals. In handling them the operator should take all necessary precautions.

The rate of application depends on the grain and the type of bin or silo. Maize normally needs double the dose recommended for wheat, and an open silo or wooden bin takes more fumigant than an airtight silo because of leakage.

A new bulk fumigation technique of great promise is the use of tablets giving off the gas phosphene in presence of moisture. These tablets are equally distributed throughout the grain mass.

Stacking Practice

Tight stacking of bagged grain is preferable to small loose stacks. A free space of 3 ft. along all walls should be maintained. Wood dunnage should be used on ordinary stone or cement floors. No bags should be in contact with any stone or iron structure.

Moisture Content

No maize, barley or oats, above 12.5 per cent moisture content, should be kept in bulk or bag storage. Wheat can be stored with a moisture content up to 14 per cent. Moulding and wet-heating (caused by fungi and bacteria) will result in the storage of commodities above these limits.

General Store Construction

The chief need in store construction is to build a store which can be easily cleaned. Walls and floors should be free of insect-harbouring cracks. There should be an absolute minimum of corners. Internal supporting structure must be minimized ("H" and "L" shaped iron structure being one of the worst offenders).

Floor Construction

The floors should be constructed to serve two purposes:—

(*a*) They must be relatively impermeable to passage of moisture from the underlying soil.

(*b*) They must be of a "warm" material (a poor conductor of heat), for if the floor is kept cold by the underlying cold earth, the moisture in the warm grain will move (translocate) to the surface next to the floor.

A material meeting both requirements is not easily found. Therefore, a compound floor is often the best. An impermeable layer of asphalt or bitumen paper combined with a concrete brick layer answers these needs, but as always care must be taken to keep cracks to a minimum. The use of wooden dunnage should not be necessary if the floor is properly constructed. The dunnage simply creates an air space which satisfies the above-mentioned two requirements.

NOTES ON ANIMAL DISEASES*

I—REDWATER AND ANAPLASMOSIS

Compiled by the Department of Veterinary Services, Kenya

(*Received for publication on 23rd April, 1959*)

REDWATER

Redwater is a tick-borne disease generally distributed throughout East Africa. On farms where dipping is not practised, every calf contracts the disease on the average 15 days from birth. Where dipping has reduced the tick population to a low figure, however, cattle may escape infection during calfhood, and severe losses may occur if they are moved to a farm where infected ticks still exist.

Cause

Several species of related protozoon parasites which produce redwater in cattle are known from different parts of the world, but only one, *Babesia bigemina,* occurs in Kenya. Although there may be some difference in virulence among different strains, there is no evidence to suggest that more than one immunologic strain occurs in Africa.

The parasites may be seen in blood smears. They invade and multiply in the red cells. Attacked cells are broken down in the body, and the red pigment of the cells (haemoglobin) is liberated. Part of this pigment is converted by the liver into bile pigment, excess of which in the tissues causes jaundice, and part is excreted by the kidneys, giving rise to the characteristic symptom, haemoglobinuria, from which the disease takes its name "redwater".

Incubation Period

Following natural infection from the bites of ticks, the incubation period is 8 to 17 days. After the inoculation of blood, as during immunization with the so-called "vaccine", the reaction begins in 5 to 15 days, usually about the tenth day.

Symptoms

The first sign of infection is usually a rise in temperature. The temperature may go to 105° F. or higher. If the animal is untreated the temperature remains elevated for several days, after which it returns slowly to normal or, in fatal cases, may fall suddenly to below normal a short time before death.

In the early stages there is dullness and a staring coat, and in severe cases there is marked disinclination to feed. During the later stages oedema of the lungs may cause distressed respiration. Nervous symptoms are not uncommon, being restricted usually to an unsteady gait; but occasionally signs of frenzy appear, the animal having uneasy, staring eyes and being liable to charge anyone approaching it. Depending on the rapidity of destruction of the blood cells, a reddish coloration, varying from pale red to deep claret, of the urine may be observed early in the course of the disease or may be postponed until the fifth or sixth day of the temperature reaction. Examination of the eyes and the visible mucous membranes may reveal the existence of jaundice.

Post-mortem Appearances

The blood appears thin and watery, the serum usually being tinged red. The loose tissue beneath the skin, the outer coats of the stomach and intestines and the whites of the eyes are often tinted a golden-yellow. The muscles may be pale and flabby.

In acute cases there is often oedema of the lungs and froth in the air passages and at the nostrils. The interlobular tissues of the lungs are then infiltrated with a yellowish fluid, causing the surface of these organs to appear to possess yellow veins. The heart-sac may contain an excess of fluid, often yellowish in colour. The heart itself usually shows haemorrhages on its surface and in the lining membranes of the cavities. There may be a yellowish gelatinous infiltration around the base of the heart.

The spleen is always considerably enlarged, its pulp being soft and dark in colour. The liver is enlarged and congested; usually it has a bright orange colour on section. The gall-bladder is distended and the bile thick in consistency. The capsules of the kidneys may be infiltrated with a gelatinous exudate. The kidneys, in acute cases, are congested.

The mucous membrane of the fourth stomach is claret-coloured and shows haemorrhages on its surface. Stripes and patches of congestion and haemorrhagic spots may be present in the intestines. The urine in the bladder is port-wine or dark-brown in colour.

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* This is a revised version of "Notes on Animal Diseases—I" which was published in this Journal *4*, 297.

Differential Diagnosis

Redwater may be confused with several diseases, only three of which will be discussed here.

Cases occuring in adult cattle, not under close observation, may from a report of sudden death, and from the large size of the spleen seen at post-mortem examination, be confused with anthrax. The appearance of the blood is usually sufficient to distinguish anthrax from redwater, for in the former disease it is very dark, often black in colour, and tarry in consistence.

The stiff gait observed in redwater is not infrequently mistaken for a symptom of heartwater. Redwater cases showing stiffness, however, have almost always reached the stage at which the urine is characteristically coloured.

Finally, the appearance of the urine in redwater is due to pigment only. This appearance must not be confused with the presence of actual blood and blood clots in the urine, a symptom characteristic of enzootic haematuria. This latter is a chronic disease, usually found in cows and work oxen, which appears to be restricted to certain parts of the Limuru, Kericho, Hoey's Bridge and Nakuru Districts; the cause is unknown but the disease is most often seen in areas where bracken grows.

When submitting smears for confirmation of diagnosis, smears taken from the ear vein should always be sent. Blood is always present in the spleen, but it is often difficult to detect parasites in spleen smears.

Transmission

The most important tick vector in Kenya is *Boophilus decoloratus*, the common blue tick. This tick is a one-host tick; that is to say, it spends its whole life on one animal, not dropping to the ground to moult between the larval and nymphal or between the nymphal and adult stages. The engorged females drop to lay their eggs and the larvae that hatch obtain a host in the usual way. For such a tick to transmit a parasite from one host to another it is of course obvious that the infection must pass through the egg. Infection has also been shown to pass through the egg in the case of a two-host tick, *Rhipicephalus bursa*, but this tick does not occur in East Africa. With *Boophilus decoloratus* it has been proved that, once a batch of ticks is infected, several generations may be passed on insusceptible animals without the infection being lost, and with *Rhipicephalus bursa* that the feeding of the larval-nymphal stage of infected ticks on a horse failed to render them, after moulting to adults, non-infective for susceptible cattle.

Less effective transmitters are *Rhipicephalus appendiculatus*, the brown tick, and *R. evertsi*, in neither of which has it been possible to demonstrate the transmission of infection through the egg.

While definite information on the point appears to be lacking, it is probable that, as in the case of tick fever in the dog and East Coast fever in cattle, a tick is not able to infect cattle with redwater until it has been feeding for three or four days.

Treatment

Three different drugs are available which have a specific action on the parasites; these comprise "Berenil", phenamidine isethionate and quinuronium sulphate (the last named is sold under trade names of "Acaprin", "Acapron", "Babesan", "Diveronal", "Pirevan", "Pirocyl", "Piroparv" and "Piroquin"). All are given subcutaneously. "Berenil" is available in crystalline form and should be dissolved in water immediately before injection. Phenamidine and quinuronium are retailed as stable solutions for injection. Dosage of all three drugs is on a bodyweight basis and should be carefully carefully calculated. Overdosage of a weakened animal can cause collapse soon after administration of the drug.

Symptomatic treatment is also of value. Convalescent animals should be given haematinics to restore blood cells destroyed by the parasites; 3 to 4 oz. of a good proprietary mineral lick suspended in water and given daily as a drench is useful for this purpose.

Preventive Measures

The preventive measures against redwater are dipping and protective inoculation. As dipping and inoculation can be used simultaneously against both redwater and anaplasmosis, discussion of these measures is postponed until the latter disease has been described.

ANAPLASMOSIS (TRUE GALLSICKNESS)

This disease occurs on all farms where redwater is present. Where dipping is not carried out, calves go through anaplasmosis during the early months of life. Imported European cattle, and a percentage of cattle from farms where dipping from birth is practised, are highly susceptible.

Cause

Anaplamosis is due to a microscopic parasite which invades the red blood cells. In blood smears the parasites are seen as a black dot occurring on the margin or in the centre of the cells. In the former case the parasite is *Anaplasma marginale* and in the latter *A. centrale*. As the parasites are very small and show no characteristic internal structure, care should always be taken that good clean blood smears are submitted for diagnosis. It is not always possible to give a definite diagnosis from spleen smears.

It is the exception to find *A. centrale* in cases infected naturally. A strain of this parasite, which produces a milder form of the disease, is used in the immunization procedure.

In calves reared under ranching methods anaplasmosis is a very mild disease. Calves that are hand reared are somewhat more susceptible, although in these also, providing that they are properly fed and are free from complicating diseases such as paratyphoid, the reaction should be so slight as to pass unnoticed.

The term "gallsickness" is used loosely to cover a variety of conditions, mainly digestive disorders.

Symptoms

The symptoms in many respects resemble those of redwater, except that red urine is not passed. The first indication of infection is a rise in temperature, usually gradual, but sometimes rather sudden. The animal appears dull, there is a staring coat and disinclination to feed. Constipation is usually marked, but in the later stages diarrhoea may supervene. As in redwater, oedema of the lungs may occur.

During the acute stage the skin and visible mucous membrane may have a yellowish colour. When this stage has passed it is usual to find marked anaemia, manifest in a paleness of the eyes, lips, gums, and of the vulva in female stock. The tongue is usually notably white.

Death may occur in the acute stage, but some of the animals that survive this die later of anaemia and cachexia.

Post-mortem Appearances

The characteristic appearance is that of a jaundiced condition of the tissues. In protracted cases the carcass is emaciated, the flesh pale and the blood pale and watery.

The lungs are sometimes oedematous, a frothy fluid exuding from the surface when cut. Froth may be present in the windpipe. The chest cavity and heart-sac may contain an excess of yellowish fluid. The heart may show patches of small haemorrhages on the surface and either patches or stripes of haemorrhages on the linings of the cavities.

The liver is enlarged and usually yellowish-brown in colour. The gall-bladder is distended and thickened with yellow or orange bile. The kidneys may be congested. Usually they are stained yellow. The urine is pale.

The spleen is often enlarged and the pulp soft in consistence. In animals that die several days after the acute symptoms have subsided this organ may appear thin and shrunken. Lesions in the fourth stomach and intestines vary in intensity. The fourth stomach may show haemorrhagic points and the intestines contain a quantity of mucous; in some instances acute inflammation of these organs is present.

The lymphatic glands are usually enlarged and flabby.

In chronic cases and in calves diagnosis may be impossible from an examination of the carcass, which may reveal little except cachexia and a pale watery condition of the tissues in general.

Transmission

As with redwater, the most important East African transmitting tick is *Boophilus decoloratus*. Members of many other tick genera (*Amblyomma, Hyalomma, Dermacentor, Ixodes* and *Rhipicephalus*) can transmit anaplasmosis, but hereditary transmission has only been proved in some varieties of *Boophilus annulatus, Rhipicephalus simus* and a tick that does not occur in East Africa, *Ixodes ricinus*. It is very doubtful if transmission through the egg ever takes place in *Rhipicephalus bursa* and *R. appendiculatus*.

In America outbreaks of anaplasmosis have been attributed to direct transfer of blood from animal to animal during the operation of dehorning and while bleeding cattle for contagious abortion agglutination tests. This can undoubtedly occur. Biting flies of the genus *Tabanus* have also been blamed for mechanical transmission.

Treatment

Unfortunately, no specific drugs of efficacy comparable with those used in redwater are available for the treatment of anaplasmosis. A considerable amount of work is being done on this subject by the United States of America, Bureau of Animal Husbandry, scientific staff. Owing to the fact that the disease is restricted to certain States, ample supplies of highly susceptible adult cattle are available for experiment in America, whereas in Kenya, cattle have to be reared in stables under tick-free conditions until they are at least a couple of years old before they are really suitable for testing the effects of the various drugs.

Symptomatic treatment and careful nursing are of considerable value. The animal should be placed in a comfortable, dry stable and given green fodder and good hay. Sloppy mashes with the addition of molasses help to provoke thirst and to prevent constipation. Any tendency to constipation should be corrected by a dose of linseed oil or salts with 25 to 35 grains of calomel. Purgatives such as carbachol given by injection have proved very useful. If the animal appears depressed or refuses food, stimulants such as ammonium carbonate and nux vomica should be given two or three times daily.

Aureomycin has been shown to antagonize the parasite, particularly if given during the incubation stage of the infection but is too expensive for all but the most valuable animals. Other drugs such as chloroquin sulphate and "spirotrypan forte" are frequently given but controlled experiments have not so far provided any support for their use.

Published reports suggest two methods of treatment as worthy of further investigation. The first consists in the administration of large quantities of blood from a healthy ox intravenously. This method, which really amounts to a blood transfusion, is not to be recommended for routine use in Kenya, since there is a risk of transmitting redwater from the donor to the sick beast and since large doses of blood given intravenously to cattle are liable to produce death from shock. The other method is to fill the stomach daily with water until it is "comfortably distended". This is done by the use of a stomach tube inserted via the mouth into the gullet. Such a treatment is well worth trial in valuable animals.

ASSOCIATION OF ANAPLASMOSIS WITH THE PARATYPHOIDS IN YOUNG ANIMALS

It is a well-established fact that anaplasmosis is often associated with one or other of the two paratyphoids commonly affecting calves in Kenya. Anaplasmosis alone very rarely proves fatal to locally born young calves. Similarly, mortality is never so high where paratyphoid infection is not complicated by anaplasmosis. These facts explain why so-called paratyphoid deaths are often reduced by attention to regular dipping, although the infection is not necessarily eradicated from the farm.

It will be apparent that when calves are said to be dying from one of these diseases, it is always necessary to take active measures to make sure that the deaths are not attributable to both conditions acting at the same time. Therefore, if on blood smear examination it is thought that the calf died of anaplasmosis, it is advisable to send a fresh piece of liver, without preserving it, for bacteriological search for paratyphoid organisms. Similarly, when paratyphoid is diagnosed, a search for anaplasmosis should be undertaken immediately, and blood smears examined.

There is hardly any need to emphasize that preventive measures against this combination of diseases entails a checking of the dip, together with the use of paratyphoid vaccine on all young stock.

COMMON PREVENTIVE MEASURES AND IMMUNITY

Dipping

The obvious method of preventing the occurrence of redwater and anaplasmosis is to eliminate the transmitting ticks by dipping. By reducing the number of ticks, other tick-borne diseases such as East Coast fever and heartwater are also controlled, and there is little doubt that a cattle dip is one of the first essentials for a farm where stock are to be kept. It should be remembered that the usual vector of these diseases is the one-host blue tick, *Boophilus decoloratus*. It is this species which has proved itself capable of resisting various types of dipping materials not only in East Africa but in many other parts of the world as well.

If the presence of a resistant strain of blue tick is suspected on a farm, ticks should be sent to the laboratory for definite identification together with a brief history of types of dip used in the past on the farm in question. Under-strength dipping and spraying or the importation of resistant blue ticks on cattle from other districts are probably the explanation of a resistant strain on a farm. Only by changing the type of dipping material can one hope to control resistant *Boophilus*.

Larval blue ticks can live for about eight months without a host. If a farm is well stocked and dipping regularly carried out in a dip kept up to proper strength, the majority of blue ticks on the grazing should be killed in about eight months.

Dipping, even at intervals of seven or 14 days, by killing off the majority of blue ticks soon results in a percentage of cattle reaching maturity without having passed through an attack of redwater and anaplasmosis. Short-interval dipping combined with thorough hand-dressing results in this stage being reached earlier. Mortality from these diseases in adult cattle may now occur. It is the practice on many farms to leave calves undipped until several months old in the hope that they will become infected and lose their susceptibility. This practice is most unsatisfactory, for it prolongs the low-tick-infestation period indefinitely. There is little point in taking vigorous steps to eradicate ticks on adult cattle and at the same time breeding them on the calves. The eventual goal is presumably the complete eradication of ticks from the farm, and every step should be taken to attain this end as soon as possible. During the transition period calves may be given a dose of redwater-anaplasmosis blood which will ensure, with much more certainty than if infection had been left to ticks, that they become infected with these diseases, and in a reasonably short time the danger period will be over.

Immunity

Animals that have recovered from redwater and anaplasmosis infection continue to harbour the parasites in their blood for varying periods of time. In redwater, infection has been known to persist for from 12 months to 12 years after removal from any possible source of reinfection. In such animals parasites cannot be found on microscopical examination of the blood; but although to all appearances they are in perfect health, their blood, on inoculation to susceptible cattle, will transmit the diseases.

Reinoculation of recovered cattle with redwater and anaplasmosis will not cause any noticeable reaction. However, if a large dose of multiplying redwater parasites is given, parasites may be detectable in the blood again for a few days. Therefore, although they are immune the condition of recovered redwater-anaplasmosis animals differs from that of animals that have recovered from a disease like rinderpest, from which the virus cannot be recovered, and the name "premunity" is now used for the former condition. Animals in the premunized state may show relapses when attacked by another disease, such as East Coast fever, or when exposed to such detrimental influences as long railway journeys or marked changes in altitude.

Inoculation

The system of preventive inoculation against redwater consists in inoculating blood from a recovered redwater animal so that a reaction to the disease occurs while the inoculated animal is under close observation. Actually inoculation of blood containing the parasites of redwater usually results in a milder reaction than when infection is contracted from the bite of the tick. By taking the temperatures each morning and evening throughout the time that the reaction is to be expected the first sign of infection is detected. If the temperature goes above 104° F. or the animal refuses to eat, a proper dose of one of the drugs listed previously should be given.

Protection against anaplasmosis is effected by a similar inoculation with the blood of an animal harbouring *A. centrale*, which produces a milder reaction than the wild *A. marginale* and gives a certain amount of protection against the latter parasite.

Cattle undergoing inoculation must be kept under tick-free conditions until the reactions to redwater and *A. centrale* are over. The ground around the stable in which they are kept should be cleared of grass for a distance of ten feet and should be kept clean. The cattle should be exercised on a piece of hard ground free from grass. Fodder and other foodstuffs should be free from ticks.

When inoculating imported cattle the usual procedure is to inoculate both redwater and *A. centrale* vaccines after about a month of acclimatization to East African conditions.

The reaction to redwater begins from five to 15 days after inoculation. Slides should be submitted daily during this period until a diagnosis of redwater is received. If necessary, that is if the temperature rises above 104° F. or the animal refuses food, treatment should be given. The period between inoculation of the blood and the first signs of reaction to

A. centrale varies from 30 to 50 days and the redwater reaction is therefore completed by this time. The duration of reaction is from four to 40 days. Slides should be submitted to a veterinary officer or to the laboratory during the time that the reaction is to be expected, every other day, until a confirmation of the presence of the parasite is received. Slides should then be sent at weekly intervals so that the state of the animal's blood can be followed. In all cases when submitting smears the date of inoculation and type of vaccine, together with the animal's temperature, should be stated on the slide folder. In addition to slides at the stated periods, slides should be sent for examination at any time that the animal's temperature shows an abnormal rise.

In some cases imported calves may be adjudged so fit that a shorter period of acclimatization is given. In other cases calves may be weak and vaccines should be given singly; the reaction to one is then carefully checked and completed before administering the second.

When inoculating cattle purchased locally it is advisable to inoculate redwater along with *A. centrale* vaccine. The question of acclimatization does not arise, and the sooner the reaction to redwater is over the better, as danger of a chance reaction from infection by the stray tick is reduced.

Generally speaking the inoculation of in-calf cows and heifers is not recommended. During the early months of pregnancy the procedure is usually free from risk of abortion, but the advice of a veterinary officer should be obtained when such inoculations are contemplated.

Young calves, if properly fed and in good health, may be inoculated with redwater and *A. centrale* and left without further special attention. The reactions should be so mild as to pass unnoticed. On many large estates it is customary now to inoculate monthly or two-monthly batches of calves between six to 12 weeks of age with such blood. Reactions are hardly noticed and a serviceable immunity appears to be developed.

It should be remembered that the vaccine is not a vaccine in the true sense of the term. It will not prevent the condition known as anaplasmosis in calves. For this condition to occur in calves, the vitality of the calf must be lowered by some other factor, and this factor is just as likely to provoke a severe reaction to the vaccine as during the course of infection naturally contracted from ticks. To control anaplasmosis in young calves, attention should be given to feeding, housing, and to the elimination of paratyphoid, bacillary necrosis and other calf diseases.

REVIEW

FODDER FARMING IN KENYA, by G. R. Henderson and P. T. Preston, published by the East African Literature Bureau, Nairobi, Kenya, 1959, 149 pp., price Sh. 10/50.

The title of this book explains its content. The authors are concerned with knowledge of the best fodder crops to grow and the most efficient and easy methods of handling and preserving the material produced. They have assembled much, if not all, of the information available on the subject of fodder crops and fodder conservation which particularly applies to cattle feeding in Kenya. Much of it is the result of practical tests at Egerton Agricultural College or by progressive farmers or Government farms and research stations. In other words it is concerned with local crops, local methods of husbandry and local experience. In this lies its advantage to local agriculture.

The first five chapters, covering some 56 pages, deal with the theory and practice of silage making, types of silos, handling the silage crop and feeding silage. Chapter VI is concerned with haymaking and in particular it pays attention to local conditions of drying constrasting this with the practice in more humid regions. Chapters VIII to XI contain information on the cropping techniques, utilization and feeding of the main fodder crops grown in Kenya including oats, maize and sorghum, while Chapter XII deals with the management of productive grassland. The remaining chapters provide a general guide to the value of the fodders and the methods by which they may be used for rationing cattle.

This is a welcome addition to the literature on East African Agriculture. It can be recommended to anyone concerned with mixed farming in these Territories and most will find it a convenient source of reference.

J.G.

SUGAR CANE IMPORTATION

By F. M. L. Sheffield, East African Agriculture and Forestry Research Organization, Kikuyu, Kenya

(Received for publication on 28th March, 1959)

Every country interested in the commercial production of sugar cane has a quarantine station through which all cane imported from outside the country must pass. In some countries foreign varieties are imported for use in breeding only but in others, as in East Africa, they are ultimately released to commercial growers. In neither case can the risk be taken of propagating new importations in cane-growing areas without first growing them in isolation.

The dangers inherent in the free importation of sugar cane to East Africa cannot be too greatly emphasized. The plant is susceptible to many diseases caused by fungi, bacteria or viruses. Some very serious diseases are fortunately as yet unknown in the African mainland. Examples are Leaf scald which is due to a bacterium, and Fiji disease caused by a virus. New diseases whose seriousness cannot immediately be estimated are frequently being described: these include Grassy-top described in India, and Bacterial mottle in Australia. To protect Africa south of the Sahara from these diseases the Inter-African Phytosanitary Commission, composed of British, Belgian, French, Portuguese, Federation and South African members, has agreed that any cane entering the African continent must pass through a recognised quarantine station. The E.A. Plant Quarantine Station at Muguga is so recognised.

The precautions East Africa needs to take when importing from other countries within Africa are scarcely less than those required when setts come from outside Africa, for East Africa is still free from certain diseases (e.g., Gumming, Chlorotic streak) that are present in other parts of the continent.

A disease may affect only slightly the variety on which it is imported but prove very serious when it attacks some of the locally favoured varieties. This was the case in South Africa when the bacterium of Gumming disease attacked plantations where N.Co.310 was grown. Large acreages had to be destroyed and replanted with less susceptible varieties. Similar action has been taken in Kenya because of Smut disease which was recently recorded here for the first time (Robinson 1959). How the fungus was brought in is not known, but it is quite certain it did not enter on cane that passed through a quarantine station. There it would have been easily recognised and quickly destroyed.

It is known that some varieties now growing in this country did not enter through any recognized quarantine station. It is only possible to conclude that they were smuggled. There are legal penalties for persons caught smuggling plant propagating material into East Africa; but this is a minor consideration compared with the losses they, their neighbouring farmers and finally the whole industry are likely to suffer should plant pathogens be inadvertently introduced on smuggled cane.

When a grower wishes to obtain a new variety, he should approach the Director of Agriculture in his territory. If the variety is already in East Africa, the Director will give any necessary assistance in obtaining it. If it has not already been introduced to East Africa, the Director of the East African Agriculture and Forestry Research Organization will be asked to import it. It is waste of time and valuable quarantine space to import canes that, because they are found to be disease-infected, must be destroyed. The Director of E.A.A.F.R.O. therefore approaches a research station where he knows that parent and neighbouring plants will be carefully inspected for disease before setts are selected for dispatch abroad. The person importing illegally is unlikely to have access to such reliable sources and is therefore more likely to bring in disease than when setts are officially imported. There may be some slight delay, as it is often difficult to locate a reliable source able to supply the desired variety and when it has been located, material at a suitable stage of maturity may not be immediately available.

Two setts of each variety are usually imported. They are grown in glasshouses at Muguga until the first ratoon matures: this usually takes about 18 months but varies somewhat with variety and according to the season at which the cane was received. Setts are then cut and sent by air to the Agricultural Station at Kawanda. The Uganda Department of Agriculture has undertaken to heat-treat against Ratoon stunting disease all material sent to them. They plant it at Kawanda where it is kept in quarantine in the open whilst being propagated. At the end of about a year setts are available to all East African Territories. These can be multiplied very rapidly especially if Dr. Evans' method‡ is used.

VARIETIES IMPORTED INTO EAST AFRICA 1954-8

A list of varieties imported to East Africa by Government services prior to 1954 was published in this Journal (Sheffield 1955). In 1954, a new quarantine station was opened at Muguga to be near and under the supervision of the Pathologist from E.A.A.F.R.O. This station handles all plant species but more than half the available space is usually occupied with newly imported cane varieties. Some of these have been requested by local growers through their Governments whilst others have been suggested by visiting specialists as possibly suited to the climatic conditions of East Africa. The varieties mentioned below have been supplied through the generosity of the Directors of:—

> The Sugar Breeding Institute at Coimbatore, India; The Imperial College of Tropical Agriculture, Trinidad; The Bureau of Experiment Stations, Queensland; The Experiment Station of the S.A. Sugar Association, Natal; The Mauritius Sugar Industry Research Institute; and The Department of Agriculture, Nyasaland.

A promise of other varieties has recently been given by the United States Department of Agriculture.

To all the above grateful acknowledgment is made.

Since January 1954, the following varieties have passed through closed quarantine at Muguga and open quarantine at Kawanda:

B.37172
B.4098

Co.356
Co.396
Co.464
Co.475
Co.513
Co.527
Co.602
Co.617
Co.622
Co.678
Co.775

Comus
Eros

C.P.29/291
C.P.29/305
C.P.34/39
C.P.36/111

H.32/8560
H.38/2915
H.38/4443
H.39/3633
H.39/5803
H.39/7028
H.44/3098

M.112/34
M.165/38
M.423/41

N.Co.292
N.Co.293
N.Co.376
N.Co.382

Pepe Cuca

Pindar

POJ.3016

PR.905
PR.1000

Q.47
Q.50
Q.57

The following have passed through closed quarantine at Muguga and are now held in open quarantine at Kawanda.

*B.3337
B.42231
B.47419

Co.779

C.P.29/116
C.P.44/101

†D.109

Ebène 1/37

H.37/1933

M.147/44
M.31/45

N.10
N.50/93
N.50/123
N.50/211

POJ.2940

The following are held in closed quarantine at Muguga:

Ajax

B.45151
B.49119

B.O.3
B.O.10
B.O.14

Co.349
Co.449

Co.467
Co.680
Co.684
Co.718
Co.740
Co.746
Co.765
Co.785
Co.798
Co.911
Co.991

Co.1001

Co.S.443
Co.S.510

Q.56
Q.67
Q.70

Trojan

During five years operation of the quarantine station, six imported varieties have been totally destroyed and one sett of each of two other varieties because they were suspected of being diseased. All those totally destroyed have now been re-imported.

REFERENCES

R. Robinson (1959). *E. Afr. agric. J.*, 24, 240.

F. M. L. Sheffield (1955). *E. Afr. agric. J.*, 21, 10.

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* This variety was already available in East Africa but was reimported as existing stocks were largely mosaic infected.

† This variety is highly disease susceptible and was imported for experimental purposes only.

‡Details of this method can be obtained from the Director, E.A.A.F.R.O., P.O. Box 21, Kikuyu, Kenya.

NOTE ON MECHANICAL BUSH CLEARING

By **P. E. Glover, E. C. Trump and R. Williams, Department of Veterinary Services, Kenya**

(*Received for publication on 6th April, 1959*)

There is a growing interest among farmers, ranchers and Government departments in bush control, particularly with tractors, and, as the Veterinary Department has now acquired some experience in this field, it is thought that this may be an opportune moment to present a brief review of our work, which may be of some assistance to those who are interested.

The only published work we know of on this subject is that of Bunting *et al.* (1955) and the earliest compilation of information on mechanical clearing in Kenya was made by R. Smith (1955).

During the years 1955 and 1956, some 32,000 acres (50 square miles) of bush was cleared by bulldozers under contract from commercial firms, the work being directed by technical officers of the Veterinary Department. The total amount expended during this period was £56,700, at an overall cost of Sh. 35 per acre. This compares favourably with Sh. 45 and upwards per acre for equivalent hand operations (clearing and piling, with some stumping) by paid labour, particularly since the latter figure does not include transport charges, which are inevitable with paid labour but non-existent with mechanical clearing.

It was found that, in heavier bush, the blades of the bulldozers must be used throughout. "Blading" cost Sh. 43/47 per acre in Athi-Tiva, Sh. 61/66 per acre at Kako near Makueni, Sh. 46/25 per acre in Simba, Area 6, and Sh. 100 per acre at Kiboko, where a somewhat over-zealous Field Officer in charge of the work insisted on its being carried out with great thoroughness. The varying costs are partly, but not entirely, due to the differences in density of the bush encountered. Certain types of tractors are more efficient than others, whilst the method of planning the work and its supervision also have their effects. Considerable experience in economical planning of work has now been gained and it has been shown that lighter tractors may cost more, per acre cleared, despite their lower running expenses.

In lighter bush, a heavy chain weighted at the centre can be dragged by two bulldozers (with a third in reserve). Small trees and heavy bushes are uprooted but the smaller shrubs, such as *Acacia pennata*, tend to bend over and escape destruction. "Chaining" cost Sh. 18/51 per acre in Athi-Tiva, Sh. 24/66 per acre in Simba, Area 6, and Sh. 23/80 per acre on the Nguu Barrier at Simba.

In spite of its cheapness, "chaining" is not always entirely satisfactory. At Athi-Tiva, it was observed that there was poorer grass cover and more regeneration on "chained" areas. The improved grass cover of "bladed" areas results from the increased breaking-up of compacted top soil by the blade and the tracks, as the tractors run over more ground than when "chaining". In this way, run-off is impeded and grass seeding is accelerated.

Whereas "bladed" areas can be used for grazing as soon as grass is established after burning the trash, "chained" areas usually require a second burn a year later to control regeneration. The second burn is dependent for its success upon a good grass cover, which means that grazing must be postponed until the second year after clearing.

Mechanical clearing is only possible on suitable terrain. Bulldozers cannot work on rocky hills, exposed lava flows or in gullies. Since most tsetse habitats contain such formations, it is rarely possible to achieve complete eradication by bulldozers alone and hand labour must be used to supplement them.

The use of too light a type of tractor can produce effects similar to those resulting from "chaining". At Kako, where lighter tractors were used, regeneration of *Acacia pennata* has been serious, although the tractors worked only with blades. In heavy bush, the blades tended to lift and duplicate runs had to be made; despite this, some of the denser thicket species were not uprooted.

In August, 1958, a contract for £17,000 was undertaken with the Mowlem Construction Company Limited, for clearing upwards of 4,000 acres of *Olea* and *Euclea* evergreen forest and scrub on the Ol Choro Orowa ranch in the Mara river area. By the end of September, 1,720 acres had been "bladed" at an average cost of Sh. 81 per acre. This type of vegetation is the most difficult yet encountered to remove with machines. The soil on which it grows is heavy black clay and it was found that, although chains were able to pull out the larger trees, they slipped over the top of shrubby material and smaller trees, even with a two-ton weight attached to the end. "Blading" is also very difficult on this type of bush and is consequently slow. The work on the Ol Choro Orowa ranch was completed at the end of December and 4,725 acres were cleared in 3,505 tractor hours, at an average cost of Sh. 71/95 per acre. "Blading" worked out at Sh. 83/62 per acre and "chaining" at Sh. 39/11 per acre.

It can be seen from Table I that regeneration cost more to clear than virgin forest. This is due to the fact that dead stumps are very difficult to extract with machines after the bush has been felled by hand.

TABLE I

MECHANICAL CLEARING AT OL CHORO OROWA RANCH, 1958

	Hours	Acres	Acres per hour	Cost per Acre
				Sh.
FOREST—				
Blade ..	1,923	2,240	1·16	83/62
Chain ..	528	1,312	2·48	39/11
REGENERATION				
Blade ..	1,054	1,173	1·11	87/38
TOTAL ..	3,505	4,725	—	—

As an experiment, some 1,312 acres of light forest have been felled with the chain. The trash will be burnt when it is dry and the progress of regrowth will then be observed.

In West Suk, two Caterpillar D.7 tractors belonging to the Dam Construction Unit of the Soil Conservation Division of the Agricultural Department were used on both blade and chain clearing. Approximately £300 was spent in clearing rather light thorn bush in the Masol Location and it was then decided that the machines could be used to more effect in clearing some of the dense and heavily fly-infested thickets of the Wei Wei Location.

The D.7 tractors were capable of blade-clearing two acres per tractor hour or chain-clearing five acres per tractor hour in fairly dense thickets. "Blading" removed all species including *Sansevieria*. "Chaining" left undamaged *Grewia villosa* and *Combretum aculeatum* but the thicket clumps were broken up and even the *Sansevieria* badly damaged. Over 600 acres were cleared in the Wei Wei Location alone; the debris will be burned when it is dry. In this area, the surface soil is badly compacted and the breaking-up effect of the tractors promises to be very beneficial.

The latest clearing operation took place in February and March of this year and involved the construction of a fly barrier to protect the Lambwe Valley Settlement. One thousand and fifty-seven acres of *Acacia-Balanites* treed grassland with *Combretum* scrub on the hillsides were cleared at an average cost of Sh. 37/80 per acre. Most of the area was "bladed" and, instead of windrowing in the usual manner, the bush was left where it fell. This method is more economical than windrowing; a test showed that one tractor was able to "blade" up to 13 acres in five hours in this way.

Table II summarizes the information discussed in this paper.

We should like to express our thanks to the Director of Veterinary Services for permission to publish this note. We are indebted to Messrs. The Mowlem Construction Company Ltd., Messrs F. E. Jackson & Company and the Soil Conservation Section of the Agricultural Department for their help and co-operation and also to Mr. R. Smith, whose work is referred to at the beginning of this paper. Mr. T. Jarrett of this department supervised some of the work in the field.

REFERENCES

Bunting, A. H., McBride, J., and Gunn, R. H. (1955). A Review of Methods of Land Clearing. *J. Sci. Fd. Agric.* 3, 121-132.

Smith, R. (1955). Guide to Mechanical Bush Clearance, Tsetse Reclamation Schemes, Ukambani. M.S.

TABLE II.—COSTS AND ACREAGES FOR MECHANICAL CLEARING OVER A PERIOD OF SIX AND A HALF YEARS

PLACE	COMMENCEMENT	TYPE OF TRACTOR USED	TYPE OF VEGETATION	SOIL TYPE	HIRE PRICE PER TRACTOR PER HOUR SH.	TOTAL COST £	AVERAGE NO. OF ACRES CLEARED PER HOUR		AVERAGE COST PER ACRE SH.		TOTAL ACRES CLEARED
							Blade	Chain	Blade	Chain	
MAKUENI	June, 1952	Caterpillar D.8	*Acacia-Commiphora* scrub	Grey to red sandy loam	93/00	7,000	2·2	—	42/27	—	3,423
SIMBA AND KIBOKO	Sept., 1952	International T.D.18.A.	*Acacia-Commiphora* scrub	Red sandy loam	74/00 68/50	10,000	1·25	—	59/20 54/80	—	3,400
ATHI–TIVA	May, 1955	Caterpillar D.8	*Acacia-Commiphora* scrub	Red sandy loam with a little black clay	97/00 plus 3/00 fuel charge	40,000	2·3	5·4	43/47	18/51	26,906
KAKO MAKUENI SIMBA	Oct. 1st, 1955	International T.D.18.A.	*Acacia-Commiphora* scrub	Grey to red sandy loam	74/00	4,600	1·2	—	61/66	—	1,523
	Dec., 1955	International T.D.18.A.	*Acacia-Commiphora* scrub	Grey to red sandy loam	74/00	3,200	1·6	3·0	46/25	24/66	1,503
SIMBA	Jan., 1955	Caterpillar D.8	*Acacia-Commiphora* scrub	Red sandy loam	96/00 plus 4/00 transport charges	3,500	1·78	4·2	56/00	23/80	1,265
KIBOKO		Caterpillar D.8.	*Acacia-Commiphora* scrub	Red sandy loam		500	1·0	—	100/00	—	100
MASAI RANCH	Aug., 1958	Caterpillar D.8	*Olea-Euclea* evergreen forest and scrub	Black clay	97/00	17,000	1·16	2·48	83/62	39/11	4,725
WEST SUK	Nov., 1958	Caterpillar D.7	*Grewia-Combretum-Sansevieria* thickets	Grey sandy loam	90/00	1,000	2·0	5·0	45·00	18/00	±1,000
LAMBWE VALLEY	Feb.–March, 1959	Caterpillar D.8	*Acacia-Balanites* with *Combretum* scrub on hillside	Heavy grey loam and black clay	97/00	2,000	Mixed blading and chaining		37/80		1,057
					TOTAL COST	£88,800	Averages:— 1·61	4·01	TOTAL ACRES CLEARED 44,902		

Average Cost of Blading and Chaining over seven years = Sh. 39/55 per acre (Say Sh. 40/00).
Average Cost of Blading alone = Sh. 59/23 (Say Sh. 60/00).
Average Cost of Chaining alone = Sh. 24/51 (Say Sh. 25/00).

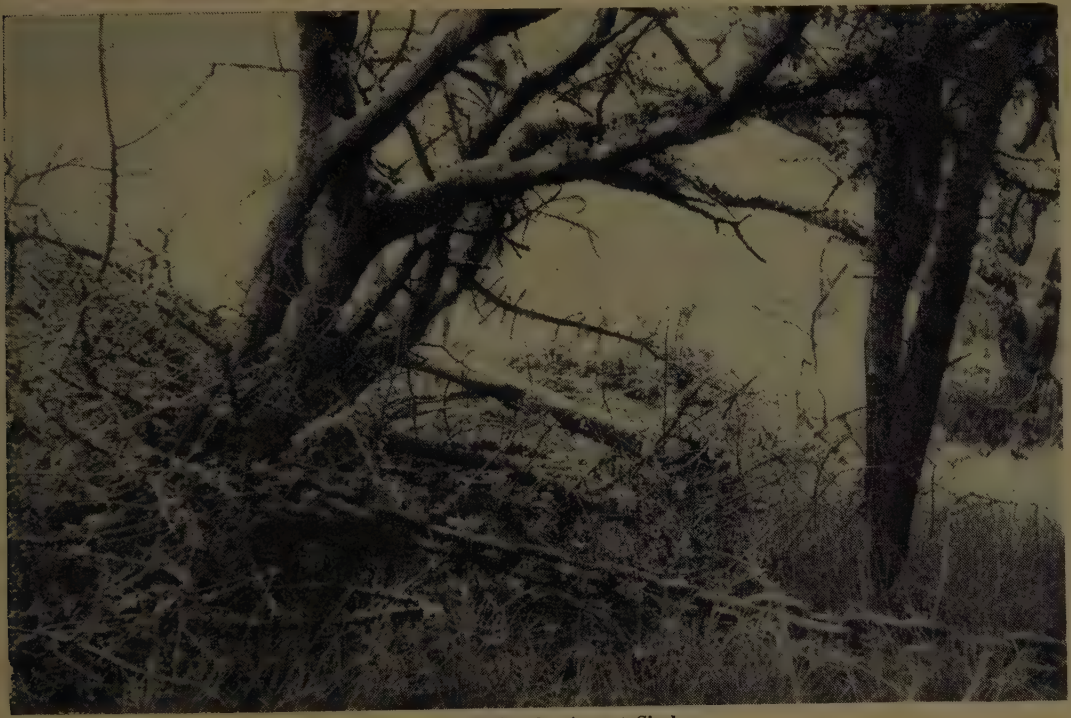
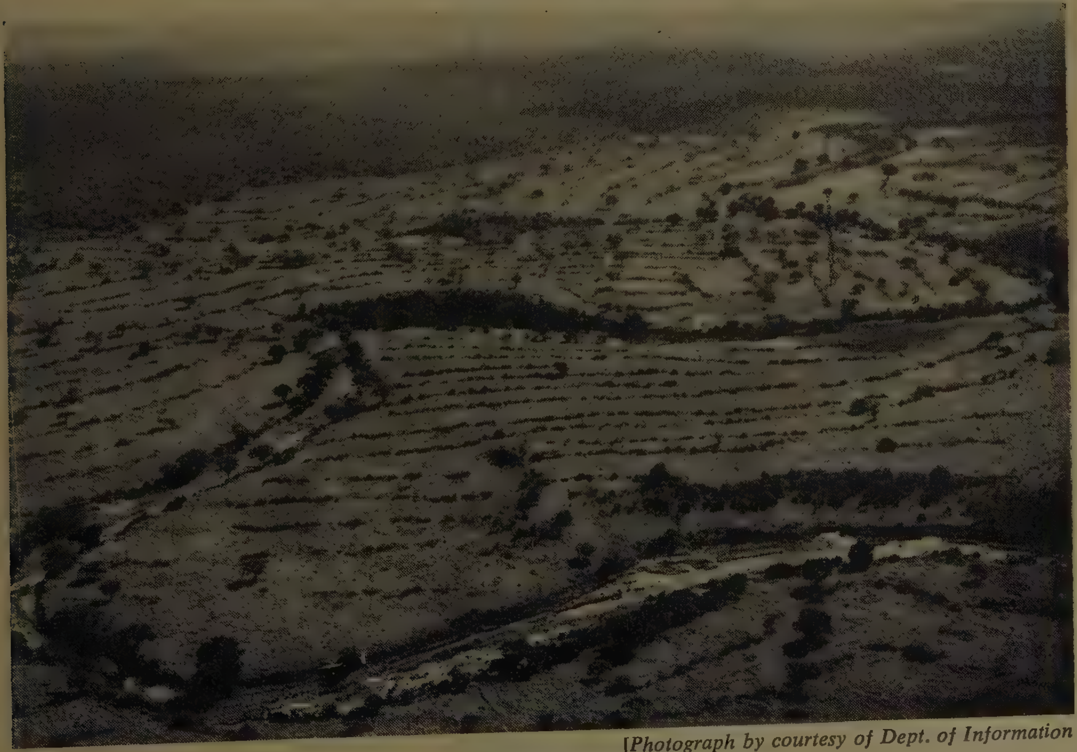


Fig. 1—Chain clearing at Simba



[Photograph by courtesy of Dept. of Information

Fig. 2—Aerial view of Simba clearing

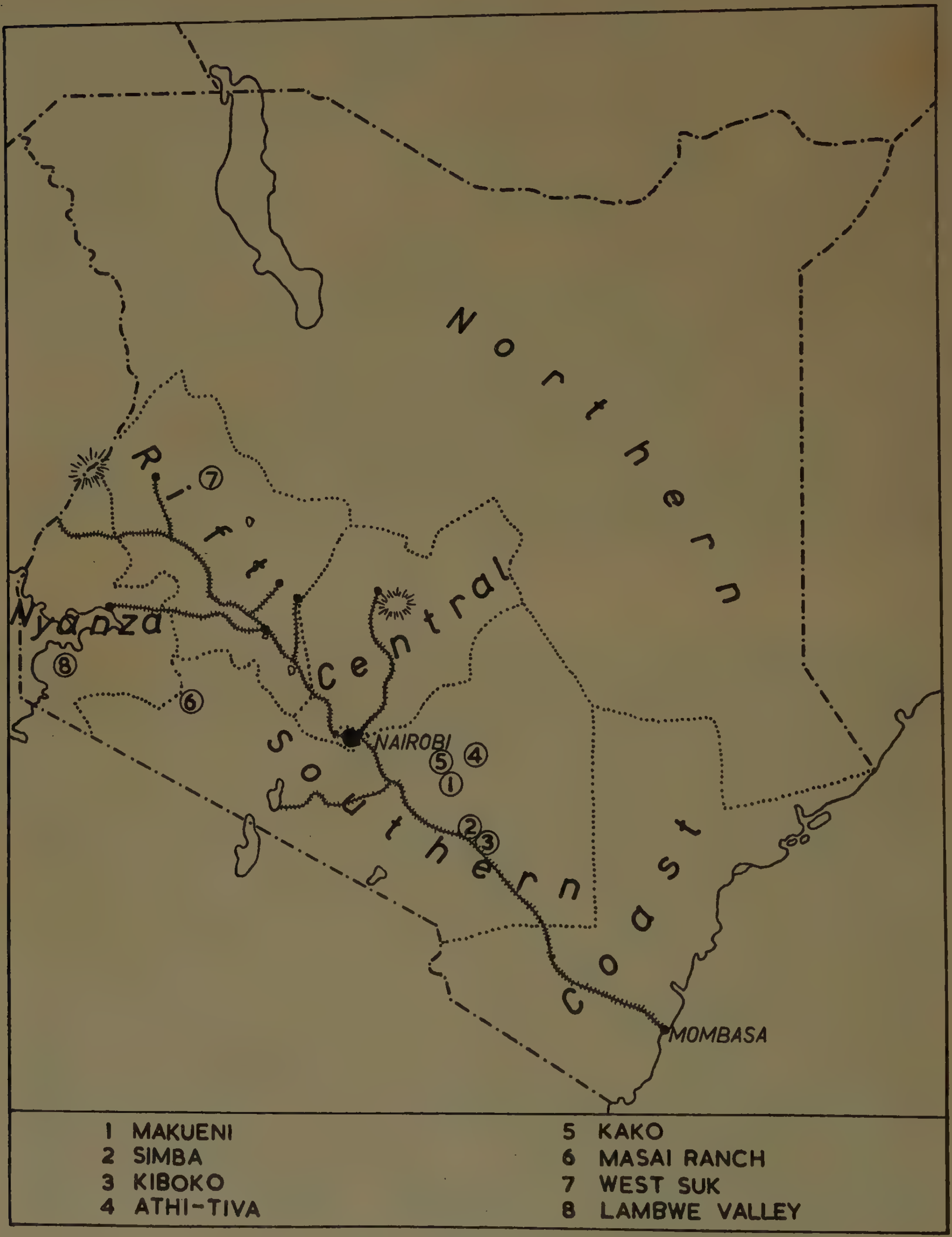


Fig. 3—Map showing sites of clearing operations.

SEED-DRESSING AGAINST THE BLACK WHEAT BEETLE (HETERONYCHUS spp.) IN KENYA

By J. F. Graham, J. A. Bullock and A. W. Peers, Department of Agriculture, Kenya

(*Received for publication on 28th January, 1959*)

Black wheat beetles (*Heteronychus* spp.) have been serious but sporadic pests of wheat and other cereals in Kenya for a number of years and work on their control has been in progress since 1951. In that year, Le Pelley and Goddard [1] experimented with Aldrin and gamma-B.H.C. in various formulations, and with different methods of application. As a result of their findings, they were able to recommend the use of Aldrin 2½ per cent dust applied with the fertilizer at a rate of 18 lb. per acre, a gamma-B.H.C. 20 per cent seed-dressing at 10 oz. per 200 lb. of seed or a gamma-B.H.C. 2.6 per cent dust applied as a seed-dressing at 10 lb. per 200 lb. of seed.

Since then various other formulations have become more readily available and experiments were conducted to discover which of these were most suitable.

In 1953, a trial comparing 20 per cent and 40 per cent gamma-B.H.C. and Aldrin 2½ per cent dust was put down, but due to the absence of *Heteronychus* no result was obtained.

Another experiment performed by Mr. A. Lacey, of African Explosives and Chemicals Industries showed that both the gamma-B.H.C. formulations exerted good control.

In 1955, an experiment was laid down at Ol Kalou [2], in which the treatments were:—

(1) Aldrin 40 per cent W.P. (which had become more readily available in Kenya) at a rate of 10 oz. per 200 lb. of seed.

(2) A seed-dressing containing 40 per cent gamma-B.H.C. plus a 2 per cent organo-mercurial fungicide at a rate of 10 oz. per 200 lb. of seed.

(3) Control.

The experiment was laid out on quarter-acre plots in a 3 × 4 randomized block design, using the wheat variety 337 as a test crop.

Seeding rates of 63 lb., 61 lb. and 71 lb. per acre were recorded for the Aldrin-treated, gamma-B.H.C.-treated and control plots respectively. The significance of this is not clear, but is probably an effect of the dressings.

No attempt was made to count the numbers of dead beetles, but a visit to the experiment about half-way through the season showed a good even stand on all the treated plots, whilst the controls were showing clear evidence of heavy beetle attack and, in all four cases, carried a very poor stand.

The experiment was harvested on 27th-28th January and the yields from the separate plots recorded (Table I). No adjustment has been made on the yield results in respect of seeding rate, as the difference between the rates for the two insecticides are negligible, and the difference in yield between control and treated plots is too great for any adjustment to affect the results.

TABLE I—YIELD IN LB. PER ¼-ACRE PLOT

Blocks	Aldrin	Gamma-BHC 40%	Control
I	264	271	111
II	303	252	109
III	298	271	101
IV	253	274	110
Mean	279·5	267·0	107·75

In this case the F test was significant at P = 0.001 and the significant difference between two means was determined as 47.49 lb. (P = 0.01). There was significant difference between the two insecticide treatments.

A further experiment in 1956 provided confirmation of the results obtained in the last experiment [2]. The experiment was on ¼-acre plots in a 4 × 4 randomized block and was laid out on a farm at Ol Joro Orok. The treatments used were:—

(1) Aldrin 40 per cent W.P. at a rate of 10 oz. per 1 lb. of seed and a 1 per cent organo-mercurial fungicide at a rate of 7 oz. per 200 lb. of seed.

(2) Gamma-B.H.C. 20 per cent plus a 1 per cent organo-mercurial fungicide at a rate of 10 oz. per 200 lb. of seed.

(3) A 20 per cent Dieldrin dressing combined with fungicide, at 7 oz. per 200 lb. of seed. This rate was adopted because of

the percentage of organo-mercurial fungicide which we were advised might cause phytotoxic effects if used at a higher rate.

(4) Control.

The experiment was sown on 1st June, using a varietal hybrid DC × Ceres 64 wheat. Soda phosphate was applied at a rate of 200 lb. per acre. Seeding rates in this experiment were 70 lb., 77 lb., 74 lb. and 79 lb. per acre in the order of the treatments listed above.

Bad weather persisted throughout the season with much much unseasonal rain, so that only rather low yields were obtained from all plots. A fairly heavy attack of beetle occurred, but it was not judged worth while to take beetle counts and the experiment was not examined critically until harvested on 12th December.

Due to the different seeding rates it was considered advisable to correct the yield using the conversion:—

$$\text{Corrected yield} = \frac{\text{Recorded yield} \times \text{Mean seeding rate}}{\text{Actual seeding rate}}$$

TABLE II—CORRECTED YIELD IN LB. PER $\frac{1}{4}$-ACRE PLOT

Blocks	Aldrin	Gamma-BHC 20%	Dieldrin	Control
I	225·7	205·7	192·1	154·7
II	224·6	218·3	193·2	150·0
III	217·1	225·1	193·0	147·2
IV	211·8	208·5	184·0	124·6
Mean	219·8	214·4	188·1	144·1

The variance ratio for treatments was found to be significant at $P = 0.001$, and the significant difference between means were found to be 11.9 lb. ($P = 0.05$) or 17.2 lb. ($P = 0.01$). Hence Aldrin and gamma-B.H.C. were better than Dieldrin, and all three were better than the control.

DISCUSSION

After 1953 it was not considered of value to continue the work on insecticide applied with the fertilizer as the cost was so much higher as compared with seed-dressing and also because it was usual for farmers to use a fungicidal seed-dressing so that the inclusion of an insecticide would cause little extra labour, and the use of a combined seed-dressing none at all, whereas mixture of the insecticide with the fertilizer would entail a second operation.

It is evident in the 1955 experiment that both dressings are most effective, giving a 2.5 increase in yield as compared with the unprotected seed.

The comparative failure of the Dieldrin dressing in 1956 is most probably due to the very low rate of application (i.e. 0.56 oz. A.I. to 80 lb. of seed compared with 1.6 oz. A.I. for Aldrin). It is likely that had a higher rate been used, Dieldrin would have proved itself effective, but there is then a danger of phytotoxic effects with the formulation used.

SUMMARY

Two experiments on the control of the Black wheat beetle (*Heteronychus consimilis* et spp. al.) are described.

The following three treatments were found to be effective:—

(1) 20 per cent gamma-B.H.C. at 10 oz. per 200-lb. bag of seed.

(2) 40 per cent gamma-B.H.C. at 10 oz. per 200-lb. bag of seed.

(3) Aldrin 40 per cent W.P. at 10 oz. per 200-lb. bag of seed.

Since there is no apparent increase in efficiency with the use of the stronger γB.H.C. only 20 per cent γB.H.C. and 40 per cent Aldrin have been recommended. Although in both experiments the crop tested was wheat, these treatments have also appeared effective when used with barley, oats and grass (first year only) under field conditions.

ACKNOWLEDGMENTS

Our thanks are due to Messrs. W. H. Goddard (1955) and J. Armitage (1956) for the provision of land, labour, machinery and materials except insecticides.

Insecticides were provided by Messrs. African Explosives and Chemical Industries (East Africa) Limited (B.H.C. products), Fisons Pest Control (Dieldrin) and Shell Chemicals Distributing Company (Africa) Limited (Aldrin), to whom we record our thanks.

The interest and advice of Dr. R. H. Le Pelley are gratefully acknowledged; and finally we wish to thank the Director of Agriculture, Kenya, for permission to publish this paper.

BIBLIOGRAPHY

[1] Le Pelley, R. H., and Goddard, W. H. (1952). *Bull. ent. Res. xliii*, pp. 403-406.

[2] Brief mention of the experiments described is made in the annual reports of the Department of Agriculture, Kenya, for the years 1955 and 1956.

MAGNESIUM DEFICIENCY IN EAST AFRICAN TEA

By E. M. Chenery, Department of Agriculture, Uganda, and J. Schoenmaekers, Office de Produits Agricoles du Kivu, Bukavu, C.B.

(Received for publication on 16th February, 1959)

Magnesium deficiency symptoms in the leaves of the tea bush were first described by de Haan [1] from sand culture experiments in Java. He states that—

> "The old mature leaves become light yellow except along the veins and sometimes the total leaf becomes light yellow, almost to white. The old leaves may also be somewhat convex and along the margins there may be brown, dead tissue at the nerve ends but this is not characteristic. Intervenal chlorosis is generally characteristic in magnesium deficiency but in some crops there may be some variation. Young leaves are normal in colour on development in contrast to nitrogen deficiency when leaves are uniformly yellow and often small."

He found tea bushes displaying the above symptoms in estates on the east coast of Sumatra. He analysed leaves from these bushes and found they were abnormally low in magnesium. It is interesting to note that de Haan gained the impression that the bushes did not appear to be any the worse for their magnesium deficiency and presumably flushed quite well.

In 1954 Tolhurst [2] reported what he considered to be magnesium deficiency symptoms in Ceylon tea as follows:—

> "Apart from poor growth, the main points of note were the dullness and brittleness of the old leaves with, in some bushes, a pronounced folding upwards along the mid-rib. The leaves were not much reduced in size. The colour was pale and without the dark-bluish green seen in a healthy leaf.
>
> "The most characteristic symptom, however, was a diffuse yellowish brown to coffee-coloured mottling which appeared as a vague mosaic between the main veins and towards the centre of the leaf. Individual bushes vary in details, but the general similarity of the symptom is apparent. The brown areas have never been seen to reach either the mid-rib or the leaf edge, or to cross one of the main veins.
>
> "It is not proposed to give chemical analyses at this stage, as there are connexions with certain conditions in the soil and it has not been possible to begin these further analyses at the present. Magnesium analyses on the leaves of bushes used for diagnosis do, however, confirm that the symptoms described are those of magnesium deficiency."

There appear to be notable differences between the findings of de Haan and Tolhurst. The latter author does not state that the leaf pattern is definite ("vague" is the term he uses), and only occurs in the old leaves, neither does he give, here or later [3], supporting analytical data for low magnesium content, both of which are diagnostic for this condition in other plants. What might have been a true magnesium deficiency in Ceylon tea has recently been reported by Roe [4]. He describes how an acute "yellowing" was decreased by spraying with Epsom salts at the rate of 1½ lb. per acre in a 1 per cent solution containing 0.25 per cent of blister-blight fungicide. No less than 36 applications were made in a year and it is claimed that a quicker break-away after plucking took place with practically no dieback. There was also 30-50 lb. per acre increase in crop and remarkable improvement in the colour of the infused leaf.

In East Africa, magnesium deficiency symptoms are most commonly seen in coffee [5] and citrus [6]. In certain very wet areas of Uganda, such as the Sesse Islands and the lake shores near Entebbe, they can be seen widespread in Robusta coffee, cassava and both wild and ornamental shrubs. The deficiency syndrome is usually the same, as de Haan also records—a distinct dark green herring-bone pattern of main veins on a yellowish-green to bronze or yellow background and very frequently a well-defined inverted green V at the base of the chlorotic leaves. Sometimes the green V can be seen without the herring-bone pattern; it is highly probable that the chlorosis is progressive from intervenal to laminal with a gradual shrinking of the green V until leaves are entirely yellow, as de Haan observed in his sand cultures. Intervenal necrosis may occur, but is not a constant feature. During 1958 both the herring-bone and green V leaf patterns were found on tea bushes growing at three sites on the western shores of Lake Kivu, Belgian Congo. They were invariably large mature leaves and were never convex. The bushes did not seem to be suffering, but one plot looked a little yellowish.

Analysis of leaves at Kawanda by E. W. Hughes, using the porous-cup spectrographic method, abundantly confirmed the field diagnosis—all patterned leaves had below 0.2 per cent magnesium on the dry weight basis and a K/Mg ratio above 10 as in the case of coffee [4]. Few figures are available in the literature for magnesium in tea leaves. Those that can be found and others hitherto unpublished are quoted in Table I for comparison with the Kivu leaves displaying the deficiency syndrome. As far as can be ascertained this is the first record for tea grown in Africa to show magnesium deficiency symptoms.

Soils in East Africa, subject to more than 45 in. of rain are generally deficient in available magnesium because they have been derived from rocks, themselves often deficient, that have been weathered for millions of years. Sooner or later the deficiency symptoms are bound to occur, especially in perennial crops. Tea, as is well known, requires an acid soil with a pH below 6.0. To a certain degree the more acid the soil, provided it is sufficiently humose, the better tea grows. The limit is probably set by the lowest levels of elements like magnesium, calcium and potassium which can be tolerated, before deficiencies occur. For the tea bush these levels must be extremely low; figures for one Kivu site are given in Table II.

Table I.—Comparison Between Magnesium-Deficient and Healthy Tea Bushes

	% Oven Dry Basis		Potassium / Magnesium
Magnesium Deficient Mature Leaves	Magnesium	Potassium	
Java, Sand Culture [1]	0·146	2·23	15·3
Sumatra, Estate A [1]	0·126	1·40	11·1
Sumatra, Estate B [1]	0·102	1·66	16·3
Belgian Congo, Tshivanga Estate, Kivu	0·096	1·76	18·3
Belgian Congo, Tshivanga Estate, Kivu	0·100	1·80	18·0
Belgian Congo, Tshivanga Estate, Kivu	0·126	1·80	14·3
Belgian Congo, African grown tea, Kivu	0·112	1·86	16·6
Belgian Congo, Nyashonya, Kivu	0·115	1·83	15·9
Mean	0·115	1·79	15·7
Healthy Mature Leaves			
Sumatra [1]	0·400	1·45	3·6
Belgian Congo, Tshivanga Estate, Kivu	0·347	1·94	5·6
Ceylon, St. Cooms, T.R.I. [7]	0·46	0·48	1·04
Uganda—Luwala Estate	0·49	0·85	1·7
Kyangu Estate	0·26	2·32	8·8
Salama Estate	0·46	0·98	2·1
Mityana Estate	0·39	2·62	6·7
Kenya—Kericho, T.R.I.	0·29	1·81	6·2
Mean	0·39	1·56	4·5

Table II.—Analytical Data for Tshivanga Topsoil from under Magnesium-Deficient Tea Bushes

pH (1:1 paste)		3·9	
Exchangeable			
Calcium	Mg and Mn by Porous-cup spark method; Ca and K by Lundegardh flame method.	0·32	Mill.—Equivalents per 100 grams soil.
Magnesium		0·58	
Potassium		0·59	
Manganese		0·05	
Total Bases		1·54	
Hydrogen (Schofield)		45·3	
Base saturation		3·3	%
Carbon (Walkley-Black)		4·36	%
Nitrogen (Kjeldahl)		0·606	%
C/N		7·2	
Phosphate (Truog)		55	p.p.m. P_2O_5

N.B.—The site had received dressings of sulphate of ammonia and on this account may be more acid and nitrogen rich than normal.

The available magnesium content of this topsoil is only one-tenth as high as a normal East African soil. Its base exchange complex is only 1.2 per cent saturated with magnesium but its potassium, phosphorous and nitrogen status would seem to be adequate. Similar acid soils exist in Uganda, either covered with rain forest or under very short-term shifting cultivation. Any consideration to plant tea in these areas should keep in view the possibility of magnesium deficiency eventually occurring. A timely warning about the same effect after regular applications of sulphate of ammonia is relevant here. R. Child in a private communication reports that A. N. Smith of the Tea Research Institute, Kericho, Kenya, has found that five annual applications of 200 lb. sulphate of ammonia in an experiment at Mufindi, Tanganyika, have reduced the available magnesium in the topsoil by 25 per cent.

SUMMARY

The symptoms of magnesium deficiency in the tea bush are described. It is believed that this is the first record for tea grown in Africa.

ACKNOWLEDGMENTS

Grateful thanks are due to Mr. E. W. Hughes for help with the analytical data, and to Dr. R. Child for his private communication. Thanks are also due to the Commonwealth Bureau of Horticulture and Plantation Crops, for a translation of portions of de Haan's paper.

REFERENCES

[1] de Haan, I. (1941). Deficiency symptoms in tea caused by a shortage of the most important mineral nutrients, with the exception of potassium. *Arch. Theecult.* (1941) *15*, 1-24, bibl. 9, *Horticultural Abstracts 11*, No. 1377.

[2] Tolhurst, J. A. H. (1954). Magnesium and manganese deficiencies in the nutrition of the tea bush. *Tea Quart.*, *25*, 84.

[3] Tolhurst, J. A. H. (1955). Future considerations in the nutrition of the tea bush. *Tea Quart.*, *26*, 37.

[4] Roe, D. (1958). Some observations on the use of magnesium sulphate for a chlorosis of tea. *Tea Quart.*, *29*, 132.

[5] Robinson, J. B. D., and Chenery, E. M. (1958). Magnesium deficiency in coffee with special reference to mulching. *Emp. J. exp. Agric.*, *26*, 259.

[6] Chenery, E. M. (1954). Minor elements in Uganda soils. *Proc. 2nd Int. Afric. Soils Conf.*, *2*, 1157.

[7] Portsmouth, G. B. (1953). Potash deficiency in tea. *Tea Quart.*, *24*, 79.

REVIEW

COMPARATIVE MORPHOLOGY OF VASCULAR PLANTS, by Adriance S. Foster and Ernest M. Gifford, Jnr., published by W. H. Freeman and Co., San Francisco, California, 1959, 555 pp., price $9.

This book is designed for the University student to whom it can be recommended as a refreshingly live approach to the subject. The first 100 pages are introductory in the sense that they give an overall picture of the organography, anatomy and reproduction of all vascular plants: this section could well be used as the basis of studies by junior students. The remainder of the book is devoted to detailed consideration of the members, including fossils, of each specific group of plants, and the variations within each group are discussed. Due weight is given not only to structure but also to ontogony, and the relation between form and function is not forgotten. That the classification used may not be acceptable to all should in no way detract from the value of the book.

Real understanding of the subject can be attained only by field and laboratory studies and writings on it are likely to be incomprehensible unless well illustrated: this book contains no less than 213 illustrations. Evan L. Gillespie is to be congratulated upon the clarity of his drawings, some of which are original but most are redrawn from illustrations in the published works of many authors. Photographs and photomicrographs are well chosen and of high quality. All are appropriately placed in the text but as the book is printed on high quality glossy paper, they lose very little in reproduction.

There is a detailed list of contents at the beginning of the book and a comprehensive index at the end. Full references to quoted works are collected at the end of each chapter.

It is unfortunate that the cost will put the book out of reach of some students in sterling areas but it should find a place in all botanical libraries.

F.M.L.S.

TOXICITIES OF VARIOUS ACARACIDES TO MITES OF THE TETRANYCHUS COMPLEX IN EAST AFRICA

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(Received for publication on 13th February, 1959)

Under local conditions, particularly during dry periods or following the use of insecticides against other pests, cotton is liable to a heavy attack of Spider Mites at present identified as belonging to the *Tetranychus telarius* complex. Damaging attacks by the same Mites have also occurred locally on pyrethrum. Since *ad hoc* attempts to control an outbreak of Mites on cotton at this Unit in 1958 with Parathion failed and the entire crop was lost, the following series of screening tests were carried out.

LABORATORY TRIALS

A number of bio-assays were carried out in the laboratory using *Tetranychus*-infested leaves which were collected from the field immediately prior to their being used. The leaves were treated by dipping, for five seconds, in emulsion or wettable powder formulations of the various acaracides, and held for 24 hours in 3 in. x 1 in. glass tubes. The tube was filled with water, and the petiole of the leaf passed through a notch in the cork into the water, leaving the lamina exposed to the air. A ring of grease round the petiole where it joined the lamina of the leaf prevented the escape of any active stages of the Mite.

Although these laboratory trials only ran for 24 hours it was found that providing the leaves were not allowed to dry unduly before placing in the tubes they would remain fresh for about 14 days if required.

Twenty-four hours after treatment the numbers of living and dead nymphs and adults on the lower surface of each leaf were counted using a binocular microscope and a glass sheet marked in quarter inch squares which was placed over the leaf to facilitate counting. Larvae were not included in these counts since they were hatching continually from the many eggs on the leaves, and it was obviously impossible to distinguish between larvae which had only just hatched and were not yet showing the effect of the acaracide, and those which had been there as larvae at the time of treatment but not killed. Resting stages and eggs were also omitted from the counts. In each test five different concentrations of the acaracide were used and at each concentration there were four single leaf replicates. Each acaracide was tested three times. Dosages and percentage mortalities were plotted on log-probit paper and the best line fitted by eye. The resulting L.D. 50's were read off the graphs and are shown in Table 1 below.

TABLE I.—PERCENTAGE OF ACTIVE INGREDIENT REQUIRED IN DIP TO GIVE 50% MORTALITY OF TETRANYCHUS TELARIUS ADULTS AND NYMPHS

CONCENTRATE USED	TRIAL 1	TRIAL 2	TRIAL 3
Metasystox 25% E.C.	0·00089%	0·00035%	0·00053%
Rogor 40% E.C.	0·00214%	0·00224%	0·00141%
Aramite 15% W.P.	0·00234%	0·00347%	0·00250%
Endrin 19·5% E.C.	0·25%	0·40%	0·20%
Dieldrin 18·5% E.C.	0·040%	0·040%	0·044%
Chlorbenzilate 20% E.C.	0·00061%	0·00125%	0·00083%
Malathion 50% E.C.	0·015%	0·018%	0·014%

TESTS ON POTTED PLANTS

Whilst these laboratory trials gave the immediate relative toxicities of the various compounds they gave little information on what the ultimate effect would be if these compounds were applied as control measures in the field. Therefore potted Castor plants, about one foot high, were infested with field-collected *Tetranychus* from cotton and a large population was allowed to build up. When the Mite population was high four plants were given a wetting spray, 5 c.c. per plant, covering both upper and lower leaf surfaces, of 0.0125 per cent Metasystox, and another four plants a similar spray of 0.0125 per cent Rogor. Leaf samples were taken from the plants at intervals, and the numbers of living and dead adults, nymphs, and larvae, counted under a binocular microscope. The results are shown in Table II.

TABLE II.—PERCENTAGE MORTALITIES OF TETRANYCHUS ON POTTED CASTOR

Treatment	DAYS AFTER SPRAYING					
	2 days Adults and Nymphs	Larvae	4 days Adults and Nymphs	Larvae	9 days Adults and Nymphs	Larvae
	%		%		%	
0·0125% Metasystox	94	83	99	83	100	99
0·0125% Rogor	100	97	100	76	96	98

Since eggs which had been laid before spraying continued to hatch during the course of the trial newly hatched and living larvae were present on each treatment at each count. Both Metasystox and Rogor were sufficiently persistent to continue killing for at least nine days.

EFFECT OF ACARACIDES ON EGGS OF TETRANYCHUS

Before carrying out any field trials a further check on the persistence of Metasystox and Rogor was carried out. Nine cotton leaves, maintained in 3 in. x 1 in. glass tubes, were each inoculated with ten adult females of *Tetranychus*. The female mites were allowed to lay eggs for 24 hours and were then removed, and the leaves treated immediately by dipping, for five seconds, in the following acaracides:—

Treatment A—0.0125 per cent Metasystox
Treatment B—0.0125 per cent Rogor
Treatment C—Nil control.

After eight days the leaves were examined under a binocular microscope, and the results are shown in Table III.

TABLE III.—MITE POPULATIONS ARISING FROM EGGS LAID IN THE TWENTY-FOUR HOURS PRECEDING TREATMENT

Treatment	Hatched Eggs	Unhatched Eggs	Live Larvae	Dead Larvae	Live Adult and Nymphs	Dead Adult and Nymphs
A. ..	104	6	0	152	0	0
B. ..	152	1	0	195	0	0
C. ..	144	66	33	4	32	1

The totals do not balance because of the difficulties in counting all stages accurately, particularly the hatched eggs, which were broken and hard to see. It should also be noted that the unhatched eggs on Treatments A and B were dead, whereas those on Treatment C were freshly laid and alive.

The results of the trial suggested that whilst neither Rogor nor Metasystox were ovicidal they were sufficiently persistent to kill larvae hatching from eggs laid as recently as the day before treatment. Therefore in the following field trials only single applications of the acaracides were made.

FIELD TRIALS ON COTTON

Cotton plants approximately 2 ft. high and planted singly at a 6 ft. by 6 ft. spacing to facilitate the spraying of single plant replicates were used. There were ten single plant replicates of each treatment arranged in randomized blocks, and the following compounds were applied as wetting sprays (70 c.c./plant) to both upper and lower leaf surfaces.

Treatment A—0.0125 per cent Metasystox
Treatment B—0.0125 per cent Rogor
Treatment C—0.1 per cent Malathion
Treatment D—0.1 per cent D.D.T.
Treatment E—Nil Control

Leaf samples were taken 24 hours after spraying and the following percentages of all active stages present were found dead. A—85 per cent, B—85 per cent, C—91 per cent, D—3 per cent, E—7 per cent.

Variations in Mite populations from plant to plant, and from leaf to leaf, were so high at the beginning of the trial, and counting actual Mite populations under the microscope so slow, that it was impossible to make actual population counts large enough to give statistically valid results. Therefore the overall results of the trial were assessed by using the following grading system:

Leaf grade:—

Nil—No living Mites present on leaf.

Light—Approximately 1-10 Mites per leaf.

Medium—Mites over approximately half of leaf area.

Heavy—Whole leaf surface covered with living Mites.

The top five full open leaves on each plant, i.e. 50 leaves per treatment, were examined at intervals and the results shown in Table IV.

TABLE IV.—NUMBERS OF LEAVES IN EACH GRADE AT VARIOUS INTERVALS AFTER TREATMENT

(*a*) Day of Treatment

Treatment	Nil	Light	Medium	Heavy
A. ..	17	24	6	3
B. ..	24	11	3	7
C. ..	12	21	11	6
D. ..	20	17	8	5
E. ..	9	21	11	9

(*b*) Seven Days after Treatment

Treatment	Nil	Light	Medium	Heavy
A. ..	44	6	0	0
B. ..	38	11	1	0
C. ..	20	9	10	11
D. ..	15	11	14	10
E. ..	4	10	5	31

(*c*) Eighteen Days after Treatment

Treatment	Nil	Light	Medium	Heavy
A. ..	18	29	3	0
B. ..	11	10	12	17
C. ..	2	11	3	34
D. ..	7	8	5	30
E. ..	2	4	5	39

Both Metasystox and Rogor were extremely effective and reduced the Mite population to well below the level at which it could do the plants any harm. Although Malathion gave a high initial kill it was neither toxic enough nor persistent enough to have any real effect on the size of the ultimate population of Mites when only a single application was made. By the end of the trial the Mite population on Treatments C, D, and E was so large that the majority of the leaves on the plants were turning yellow and shedding. Since the experiment was based on single plant replicates in randomized blocks it was possible for the plants given the more effective treatments to be reinfested from the surviving populations on the less effective treatments and the controls, and it is therefore fairly certain that on a field scale a single application of either Metasystox or Rogor would give effective control.

FIELD TRIALS ON CASTOR

A small plot of castor, planted 6 ft. by 6 ft., was infested with *Tetranychus* by placing field-collected cotton leaves bearing Mites on the castor plants. When the Mite population had built up to a high level and the plants were from 3 to 5 ft. high, two rows were treated with 0.0125 per cent Metasystox, two rows with 0.0125 per cent Rogor, and two rows were left as an untreated control. The acaracides were applied as wetting sprays to both upper and lower leaf surfaces and approximately 200 c.c. of spray was applied to each plant.

Microscopic examination 24 hours after spraying showed that 79 per cent of all active stages were dead on the plants sprayed with Metasystox and 66 per cent dead on plants treated with Rogor.

Leaf grading, as described in the cotton trial, was carried out after 13 days the results are shown in Table V.

TABLE V.—NUMBERS OF LEAVES IN EACH GRADE THIRTEEN DAYS AFTER SPRAYING

Treatment	Nil	Light	Medium	Heavy
Metasystox	38	57	5	0
Rogor ..	1	34	30	31
Control ..	0	2	11	82

Owing to the limited amount of material available it was not possible to test the acaracides in the field when applied as low volume sprays at five to ten gallons per acre, but it is hoped that this can be done in the coming season.

SUMMARY

Of all the acaracides tested against the *Tetranychus telarius* complex, Metasystox appeared to be the most effective. However, single applications of either Metasystox or Rogor applied at 0.0125 per cent as wetting sprays aimed at both lower and upper leaf surfaces gave good control of *Tetranychus* in the field. Laboratory tests showed that although neither Metasystox nor Rogor was ovicidal they did have sufficient persistence to kill Mites hatching from eggs laid as recently as the day before spraying.

In laboratory tests Aramite and Chlorbenzilate were also effective, but there was insufficient plant material available to test them in the field.

BUSH CLEARING EXPERIMENTS IN THE SOUTH NYANZA DISTRICT OF KENYA

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(*Received for publication on 31st March, 1959*)

In the Lambwe Valley in South Nyanza there is found a type of dense evergreen thicket which is difficult and expensive to remove. It occurs in large compact masses which occupy only some 7 per cent of the total area, so that its presence does not in itself constitute a serious waste of land. It is, however, a habitat of the tsetse flies *Glossina pallidipes* Austen and *G. brevipalpis* Newstead. *G. pallidipes* occurs in extremely large numbers, and, ranging out from its permanent habitat, makes it impossible to keep unprotected cattle in the valley. It would probably be possible to keep cattle under the protection of modern drugs, but such a system would introduce a serious medical risk, as *G. pallidipes* is, in Central Nyanza, the vector of Rhodesian sleeping sickness. This risk would be of indefinite duration, as the mere presence of people in the grasslands would not destroy the large thickets or remove *G. pallidipes* from them. The elimination of *G. pallidipes*, therefore, if not essential, is certainly a very desirable condition of occupying the valley. This elimination might perhaps be achieved by means of insecticides. This course has the disadvantage that, as the habitat is unchanged, there is always a risk of reinfestation. Another disadvantage is that the bush is the habitat of such vermin as bush-pig, which are always troublesome when near cultivation. The bush has little positive value. It is a source of building poles and of firewood, but if it were removed these could be obtained from individual plantations of such exotics as *Eucalyptus*, which are commonly grown in the district. In short, if it could be done economically, removal of the bush would be a good way to make cattle and men safe from trypanosomiasis.

As noted above, the thicket is difficult and expensive to remove. The difficulties arise from the facts that, on the one hand, there are about 8,000 woody plants to the acre, and on the other, more than half of these regenerate after cutting and burning, at a speed of up to 12 feet a year. Digging up the roots by hand is a very slow and expensive process. Mechanical rooting has not been tried, and the area is perhaps unsuitable for it, because the black clay soil is at times waterlogged and at other times baked hard. The intermediate times when it is thought to be mechanically workable are short and not accurately predictable. Since the area of Ruma is very flat it was once suggested that it might be possible so to site a dam as to kill most of the thicket by inundation. Survey revealed, however, that the thicket was not in the lowest part of the drainage, most of it lying on the western slope. It would have been necessary to construct a dam a-mile-and-a-half long, impounding up to 40 feet depth of water, to destroy some two square miles of thicket, and this was considered uneconomic. Ivens and Cochrane (1956) have reported an attempt to kill cut stumps with an arboricide. Although the effects of the treatments were considerable, none prevented regeneration of the two most troublesome species, *Euclea divinorum* Hiern and *Acacia pennata* (L.) Willd. We report here complementary experiments using only cultural methods.

Our experiments, like those of Ivens and Chochrane (1956) were carried out in the central block of thicket known as Ruma, which covers some 2,000 acres. An area in the middle, 50 yards north of the motor track, and 140 yards square (i.e. approximately 4 acres) was sheer felled and burnt early in 1955. The cost of this operation was as follows:—

Cutting	91 man-days
Cleaning up and burning, 8–21.3.1955	99 man-days
	190 man-days

Or approximately 47 man-days per acre.

It was noted at the time that the burning cost more and was less effective than it would have been had the cutting been done two months earlier so as to allow the trash four months in which to dry out. This, however, is a practical difficulty which arises fairly frequently, either because one cannot assemble a big enough labour gang at the right time, or for some other administrative reason.

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After the burn, the cleared area was divided into plots of one-half, one-quarter or one-eighth acre, which were treated in various ways. The design of the experiment was thus primitive, lacking replicates, and not susceptible to such detailed analysis as that of Ivens and Cochrane (1956). This was because the observations were intended to be only of an exploratory nature, and because the burn was an essential part of the experiment, and this could not have been reproduced accurately on a number of small separate plots.

We will first see what happened in plots receiving no further treatments. Table I shows the position after five months in plot E, one-quarter acre, which was then recleared at a cost corresponding to two man-days per acre. Table II follows the course of regeneration in Plot F, which was not touched. Although a considerable proportion of the vegetation was destroyed by the burn, this was partly offset by pioneer species invading the cleared area. Even after five months the thicket was well on the way to re-establishing itself, and after three years this process was approaching completion. It was not possible in this small non-isolated plot to judge when the thicket was again capable of maintaining *G. pallidipes;* but experience elsewhere in the Lambwe Valley has been that 4-foot thicket is not, whereas 10-foot thicket is, *G. pallidipes* habitat.

METHODS OF SMOTHERING REGENERATION

Of various conceivable cultural methods of controlling regeneration the only ones tried by us involved planting something which, by virtue of its rapid growth, could smother the regeneration of the indigenous thicket elements with little help. Two groups of smother-crops were tried: members of the grass family, and trees. The wisdom of planting trees in an anti-tsetse clearing in its early stages may, of course, be questioned. There is reason to believe that a pure stand of strongly growing trees with no undergrowth would not support either of the Lambwe specie of *Glossina*. To ensure the complete absence of undergrowth would entail higher expenditure on weeding gangs than might be dictated by purely sylvicultural considerations, and this would be economic only with trees producing millable timber, as opposed to species yielding poles and firewood.

Smother-crops of the grass family

Sorghum and maize each planted on an eighth-acre plot had only a limited smothering effect. This is, of course, well known from the speed with which, under regimes of shifting cultivation, thicket becomes established on fallow land. The maize was destroyed by bush-pig. The sorghum yielded at the rate of only six bags to the acre, which was considered poor, but at Sh. 25 per bag the income would have born a useful relation to the cost of clearing (47 man-days was less than Sh. 100 in 1955).

Sugar cane on a ninth-acre plot gave promising results. Planted on 16-4-55, five months later it was 66 inches high, and in 14 months 120 inches. It was weeded once, a year after planting. The cane smothered regeneration very effectively, and in an area in which it can be sold would be an excellent smother crop.

Star grass (*Cynodon* sp.) also gave excellent results. Mr. H. E. Hornby was first responsible for drawing our attention to the merits of this grass many years ago, and it has long been part of our technique of anti-tsetse clearing (*see* for example, Glasgow and Duffy, 1949 and 1951). Though regarded as a weed in cultivation, it is a valuable pasture grass. In the present experiment it was planted on a quarter acre plot on 18-4-55, spaced 3 ft. × 3 ft. This cost 12 man-days per acre. The regeneration was slashed in August, and by the end of September the grass was 30in. high and ground cover almost complete. By June, 1956, the grass formed a dense tangled mass 4 ft. high, through which only a negligible amount of regeneration could be seen.

Trees as smother crops

Quarter acre plots were planted with seeds of *Cassia siamea* Lam., *Eucalyptus citriodora* Hook, *Markhamia platycalyx* (Bak.) Sprague and *Melia azedarach* L. The *Cassia* and *Eucalyptus* grew well, respectively to 10 and 12 feet after 14 months, and 18 and 25 feet after three years. In April, 1956, seedlings were planted of seven further species: *Pinus radiata* D. Don, *Casuarina cunninghamiana* Miq., *Maesopsis eminii* Engl., *Eucalyptus microcorys*

TABLE I.—REGENERATION ON PLOT E, ONE QUARTER ACRE 5 MONTHS AFTER BURNING

	REGENERATION IN INCHES							
	Dead	Alive	1–12	13–24	25–36	37–48	49–60	61+
Euclea divinorum Hiern	4	180	33	114	21	9	1	2
Mystroxylon aethiopicum (Thunb.) Loes.	23	27	16	10	1	0	0	0
Scolopia sp.	59	75	48	25	2	0	0	0
Erythroxylum fischeri Engl.	74	17	12	4	1	0	0	0
Gymnosporia sp.	6	28	10	15	3	0	0	0
Euphorbia candelabrum Trem. ex Kotschy	18	0	—	—	—	—	—	—
Grewia sp..	0	3	0	2	1	0	0	0
Rhus natalensis Bernh. ex Krauss ..	1	46	2	13	13	13	5	0
Allophylus alnifolius (Bak.) Radlk. ..	10	34	11	16	5	2	0	0
Acacia pennata (L.) Willd.	19	16	2	2	3	6	1	2
Scutia myrtina (Burm. f.) Kurz ..	63	40	8	15	9	7	1	0
Carissa edulis Vahl	1	15	0	8	3	4	0	0
Capparis tomentosa Lam.	1	35	9	20	3	2	1	0
Maerua sphaerocarpa Gilg	0	1	0	1	0	0	0	0
Rhamnus holstii Engl.	2	2	0	1	0	1	0	0
Jasminum sp.	0	5	1	2	1	0	1	0
Opilia celtidifolia (Guill. and Perr.) Endl ex Walp.	21	4	1	0	1	1	0	1
Unidentified	15	32	14	16	2	0	0	0
TOTALS	317	560	147	264	69	45	10	5

NOTE.—The total number of stems recorded is only 3,508 per acre. Ivens and Cochrane (1956) recorded 8,000 per acre. The discrepancy is ascribed partly to variation between places and partly to the total destruction of some stems by fire.

TABLE II.—REGENERATION IN PLOT F

(No further treatment after burning, March, 1955)

	NUMBER OBSERVED	HEIGHT IN INCHES			
		19 weeks	*27 weeks*	*55 weeks*	*157 weeks*
(*a*) Marked individual stumps—					
Euclea divinorum Hiern	5	50	63	96	132
Mystroxylon aethiopicum (Thunb.) Loes.	5	18	22	—	—
Scolopia sp.	5	16	16	—	—
Scutia myrtina (Burm. f.) Kurz	5	37	44	—	—
Grewia sp.	5	51	67	96	120
Gymnosporia sp.	3	28	38	—	—
Rhus natalensis Bernh. ex Krauss	3	56	68	84	120
Allophylus alnifolius (Bak.) Radlk.	3	28	39	—	—
Carissa edulis Vahl	3	52	57	—	—
Capparis tomentosa Lam.	3	42	56	—	—
Acacia pennata (L.) Willd.	5	88	109	120	132
Erythroxylum fischeri Engl.	3	20	26	—	—
Acacia seyal Del. var. *fistula* (Schweinf.) Oliv. ..	3	32	51	120	144
(*b*) Seedlings germinating after burning—					
Sesbania sesban (L.) Merr.	4	111	127	144	264
Celosia anthelmintica Aschers.	1	113	144	—	—
Hibiscus panduriformis Burm. f.	1	72	88	—	—
Chenopodium opulifolium Koch and Ziz.	1	84	84	—	—
Sodom apple (Solanaceae)	1	24	48	—	—
Ricinus communis L.	1	77	77	—	—

F.v.M., *E. maculata* Hook., *E. robusta* Smith, and *Cupressus lusitanica* Mill. var. *benthamii* (Endl.) Carr. After two years, *Casuarina* reached 14 ft., E. *maculata* 12 ft., and *Cupressus l. benthamii* 8 ft.

It would appear that *Cassia siamea, Eucalyptus citriodora* and *E. maculata, Casuarina cunninghamiana* and *Cupressus benthamii* grow strongly enough to smother regeneration in Ruma. However it may be doubted whether any of them are sufficiently valuable to make their use for this purpose economically attractive. As mentioned before a high standard of plantation care would be necessary to ensure the elimination of the tsetse *G. pallidipes*.

CONCLUSIONS

Although these experiments were small and unreplicated certain conclusions can be drawn with safety. It is clear that in areas like Lambwe where some rain falls every month, cutting and burning without further treatment is always a waste of money. Useful sums of money could often be recovered by including one or more crops in the clearing process; this has not often been done, and a probable reason may be found in rigid Government systems of accounting, which tend to separate such revenue from the scheme which earned it. Sugar cane appears to be a promising smother crop which is worthy of further trial. Star grass, *Cynodon* sp., is perhaps the best smotherer of all. This conclusion is based on extensive previous experience as well as on the present trial. Certain trees offer promise as a means of smothering regeneration. Those most suitable for this purpose, however, are those of least commercial value. To grow trees, and keep the plantations sufficiently clean to eliminate tsetse, would cost more than to grow *Cynodon*, and it is questionable whether the value of the timber would make it worthwhile.

Finally, it may be pointed out that trials such as these cost very little, and are well worth undertaking before any clearing scheme is begun. There is no reason why the use of arboricides should not be combined with cultural methods, and in Ruma one might suppose that an application of 2, 4, 5—T to the cut stumps at the time that the *Cynodon* is planted would prove an excellent combination.

SUMMARY

Experiments were directed at discovering a cheap and permanent method of removing the dense evergreen thicket which is the habitat of the tsetse *Glossina pallidipes*.

Cutting and burning a 4-acre plot in Ruma thicket cost 47 man-days per acre.

If no further treatment were given, regeneration reached 2-5 ft. in five months, and in three years the thicket was nearly back to normal.

By planting grain crops in the ashes much of the cost of clearing can be recovered, but the grain does not of itself smother regeneration.

Sugar cane smothered regeneration effectively. This crop is worthy of further trial in any area in which there is a sale for it.

Various tree species grew fast and thick enough to smother regeneration. It is pointed out, however, that tsetse elimination would require plantations to be kept quite free of undergrowth, and the economics of tree growing are doubtful.

Star grass, *Cynodon* sp. is perhaps the most effective method known for smothering regeneration.

It is suggested that *Cynodon* might combine well with the use of a phytocide such as 2, 4, 5,—T.

Small scale trials of the kind reported here are recommended as an essential preliminary to bush-clearing schemes.

REFERENCES

Glasgow, J. P., and Duffy, B. J. (1949). Observations on lateral scour in the Kuja River, Kenya. *E. Afr. agric. J.*, *15*, 29.

Glasgow, J. P., and Duffy, B. J. (1951). Further Observations on the Extermination of *Glossina palpalis fuscipes* Newstead by Hand-catching. *Bull. ent. Res.*, *42*, 55.

Ivens, G. W., and Cochrane, D. G. (1956). Effects of 2, 4, 5—T on Evergreen Thicket Vegetation in Kenya. *Trop. Agriculture Trin. 33*, 136.

HIGH ALTITUDE LEY AGRONOMY IN KENYA

PART I—OBSERVATIONS ON THE CLIMATE AND SOIL

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The high altitude farming areas of Kenya total about 700,000 acres exclusive of main forest blocks, and they lie between about 8,000 ft. and 9,200 ft. above sea level with a few farms reaching to 10,000 ft. Historically these areas are generally recognized as having had no large resident indigenous population other than the Wanderobo on the forests and the so called "Seriqua" whose pit dwellings remain as evidence of a tribe now extinct in Kenya. The pastoral Masai did, however, graze over much of this high altitude country. European settlement started at the beginning of the century and crops grown included cereals, flax and essential oils, the last two now being seldom grown. Sown pastures are a comparatively recent innovation although a few farmers tried them on a small scale between the two world wars, without, so far as can be gathered, much success. During the last war and immediately afterwards the only ley grass in use in the high country was Kenya Bromus (*Bromus unioloides*), and to a small extent Wimmera ryegrass (*Lolium rigidum*). The former is a biennial which has now become very stemmy, probably because of the lack of any re-selection in it, and is seldom used; the latter re-seeded itself so abundantly that it encroached into arable land with such vigour that cereal production could have been threatened. Although the importation of Wimmera ryegrass was prohibited on this account, the great increase in livestock numbers since the war, and the trend towards mixed farming, warrants a new assessment of this species, since stock are now available to eat it and possibly keep it under control.

In 1949 the District Agricultural Officer of the Rift Valley, Mr. A. Storrar, started observation plots of grasses and legumes on Marindas farm, Molo [1], and the results of these showed that some of the temperate ley species could be used at the high altitudes in Kenya. In 1957 the acreage of high altitude leys totalled 20,000 acres and in 1958 this increased to 24,000 acres [2].

In 1951, 450 acres of undeveloped and derelict land, most of which had been under monoculture cereals for many years, was bought in Molo by the Agricultural Department as a grassland station to serve the high country. This station had a poor start, its development being severely restricted in its first four years by lack of capital but it is now, in 1959, fully developed and stocked, the land broken, and in a position to expand its activities. Notwithstanding, as the first phase of the station's work has been finished this is a suitable time to report the results of some of the investigations.

The present article deals with some of the grosser aspects of the high altitude climate and soils; Part II deals with phosphate and nitrogen investigations; Part III with lime, trace elements, and *legume* problems in so far as they may affect the general future of high altitude ley farming.

THE CLIMATE

Rainfall

The rainfall and temperature comparisons which follow are based on four-year averages from the Kenya stations and long-term averages from the overseas places.

TABLE I.—MONTHLY RAINFALL—INCHES

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Equator	1·92	1·29	1·58	6·32	6·17	5·50	5·16	8·53	4·59	2·21	1·72	3·05	48·04	(5-year av.)
Molo Grasslands..	3·00	1·98	2·78	6·20	6·85	6·25	6·29	10·45	6·39	2·09	2·17	2·35	56·80	(4-year av.)
Ol Joro Orok ..	1·82	1·22	0·78	4·73	4·36	3·81	4·87	6·04	3·74	1·30	2·32	1·62	36·61	(5-year av.)
Molo Horticultural Station	2·65	1·37	1·60	5·29	6·24	4·11	4·89	7·56	4·81	1·99	2·59	2·47	45·57	(4-year av.)
Dickson (N.S.W.)	2·19	1·72	1·94	1·68	1·76	1·89	1·53	1·68	1·79	2·17	2·10	2·04	22·49	(Long-term average)
Palmerston N.(N.Z.)	3·20	3·09	2·23	3·36	3·32	4·35	3·04	3·75	3·01	3·56	2·86	3·28	39·05	(Long-term average)
Long Ashton (U.K.)	3·20	3·46	2·86	0·14	1·94	1·79	4·47	3·15	4·57	3·72	2·76	2·56	34·62	(1957)

As there are large variations in yearly rainfall the comparisons of the short-term figures shown in Table I for Kenya high altitude stations cannot be precise, and the main interest is in the seasonal distribution of the rainfall rather than in yearly totals which range from 36 to 56 inches a year. Of the total rainfall three-quarters falls between April and the end of October; throughout the rest of the year the monthly totals rarely reach 3 inches, generally being between 1 and 2 inches. General experience has shown that April and May are the best months for sowing leys, coinciding with the start of the rains. Any rain received after October is apparently ineffective for pasture growth since high winds are generally experienced then. Wind speeds recorded at the Equator meteorological station (which are the highest in the records) range from 14 to 17 knots, reaching sometimes 25 knots, and this wind may often blow throughout the day as at Molo. This, and the insolation factor which largely determines the rate of evaporation [3], is probably responsible for the ineffectiveness of the late rains. The effect of heavy rains of 10 in. or more in August, when more is received than in any other month, is, however, another factor which may limit plant growth towards the end of the year because of the loss of nutrients by leaching. By comparison with the rainfall figures shown in Table I for Long Ashton (U.K.), Dickson (New South Wales) and Palmerston North (New Zealand), probably twice as much rain as they get is needed for pasture growth at Molo in the months between November and March. A seven to eight month growing season is thus considered normal locally, but pasture growth in the first half of this is generally far better than in the second half.

Temperatures (Screen)

Fig. 1 shows the mean monthly mean maximum and mean minimum temperatures for the Molo Grassland Station (altitude 9,000 ft.), the Equator Meteorological Station (altitude 9,062 ft.), the Ol Joro Orok Agricultural Station (altitude 7,800 ft.), and for comparison

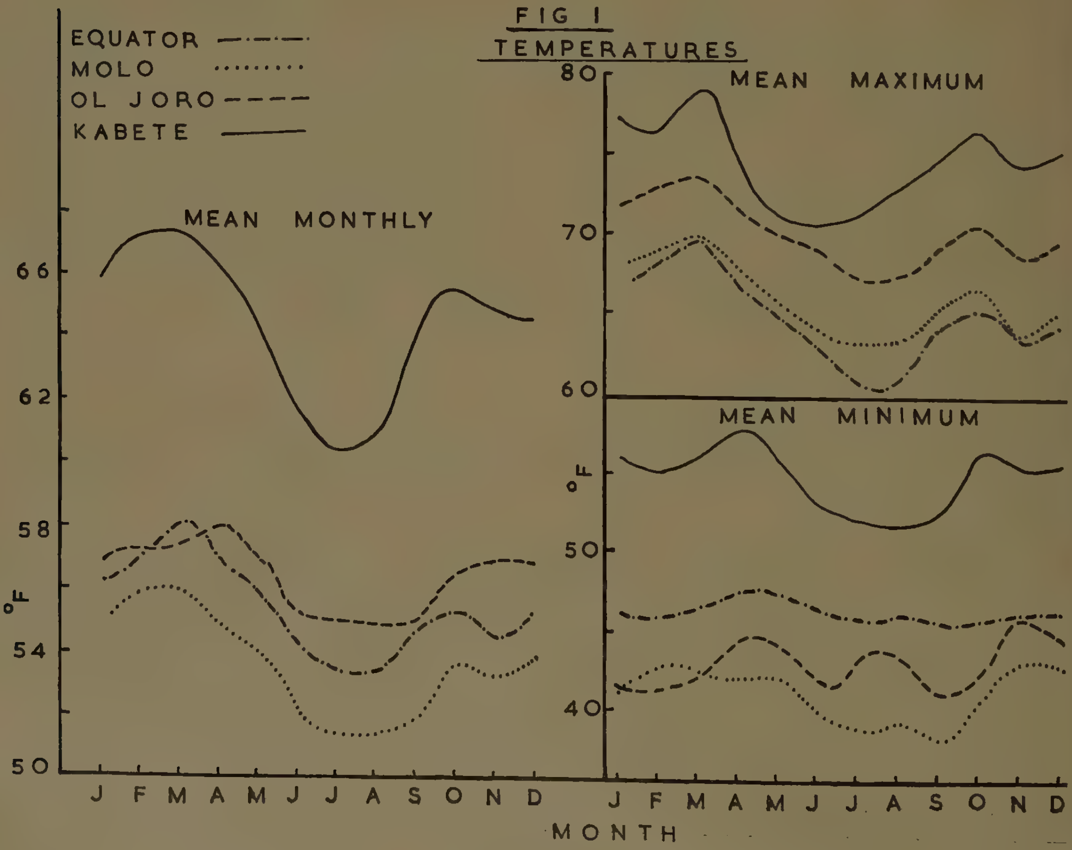


FIG I

TEMPERATURES

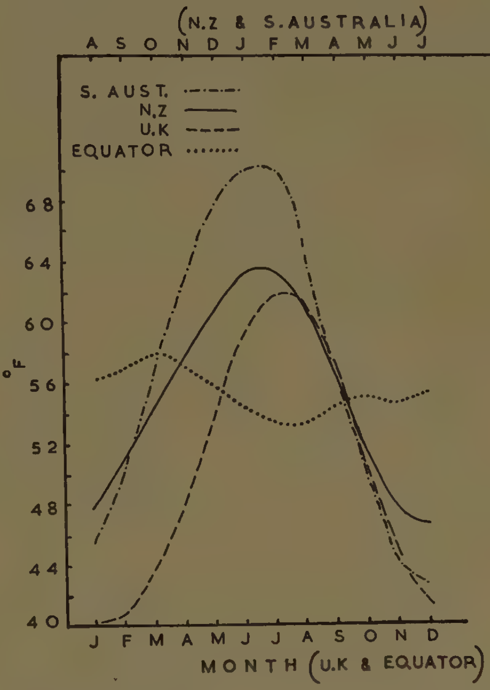
the medium altitude Kabete observatory (altitude 5,971 ft.). Data for the Molo Horticultural and Pyrethrum Station (altitude 8,300 ft.) closely follow those of Ol Joro Orok.

As would be expected on the assumption of a lapse rate of about 3 deg. Fahr. for each thousand foot increase in altitude, the high stations are about 9 deg. Fahr. colder than Kabete, but the West Rift station (Ol Joro Orok) is colder than would be expected on an altitude basis. This local depression in temperature is well known to the horticulturists, and fruit trees which demand chilling can be planted about a thousand feet lower East of the Rift than on the West. The high altitude stations show only a 3 deg. to 5 deg. Fahr. difference between the warmest and coldest months, compared to 7 deg. Fahr. at Kabete. Mean temperatures range from 56 deg. Fahr. in the hottest months to 51 deg. Fahr. in the wet coldest months for Molo Grasslands, the other high altitude stations being 2 to 3 deg. Fahr. warmer. It is of interest that the Equator meteorological station has lower maximum temperatures and higher minimum temperatures than either Ol Joro Orok or Molo. Generalizations are thus dangerous, even when comparing stations of the same altitude and situated within 40 miles of each other on the same side of the Rift Valley.

Taking Equator as typical of the high altitudes, it is of some interest to compare its climate with other countries (Fig. 2). Compared with Long Ashton in England, it is clear that, over the summer period of May to August, Equator is up to 10 deg. Fahr. colder, being typified by continuous late English spring or early autumn temperatures. Dickson in New South Wales (a typical subterranean clover or lucerne area) and Ruakura in New Zealand (a good ryegrass/white clover area) are also warmer than Equator for about five months of the year in spring and summer. For seven months of the year Dickson has higher mean maximum temperatures, and for five months higher mean minimum temperatures, than Equator. In New Zealand, maximum temperatures show little latitudinal differences [4] and even in the South Island maxima may reach 90 deg. Fahr., though generally in the 65 to 75 deg. Fahr. range; minimum temperatures, excluding those of mountainous uninhabited regions, range from 46 deg. Fahr. in Auckland to 35 deg. Fahr. at Christchurch (South Isle), central Otago having the severest winter with temperatures down to 28 deg. Fahr.

FIG 2

M.M. TEMPERATURES



Without going into greater detail it is evident that in Kenya the high altitudes have generally lower temperatures during much of the growing season than these other temperate climates during their late spring and summer months. Within Kenya, altitudes of from 8,200 ft. upwards (West Rift) and from 7,800 ft. (East Rift) may be nearly 7 deg. to 10 deg. Fahr. colder than the medium altitudes.

Sunshine

Fig. 3 shows some comparisons of sunshine records. It is clear that during the local winter months May, June, and July, Ol Joro Orok and Molo Grasslands receive less sunshine than does Aberystwyth or Long Ashton in summer, but about the same as Ruakura in its summer.

Soil Temperatures

These are normally taken under bare soil. Such readings are no real indication of soil temperatures under vegetation but there are many difficulties when covered-soil temperatures are compared, because of height of cover, colour, plant density, type of leaf, etc. [5]. Notwithstanding, data are shown in Fig. 4 for the 4 in., 14.00 hours; soil temperatures under swards at Molo Grasslands [6] (natural veldt grasses), Rukuhia, New Zealand [7] and at Jeallots Hill, England [8]. The figures relate to one year only. It is clear that the soil temperatures under grass are far higher during summer, and, as would be expected, lower in winter, at Rukuhia and Jeallots Hill than at Molo Grasslands. The absence of any major fluctuations in soil temperatures at Molo is noteworthy.

FIG 3

SUNSHINE

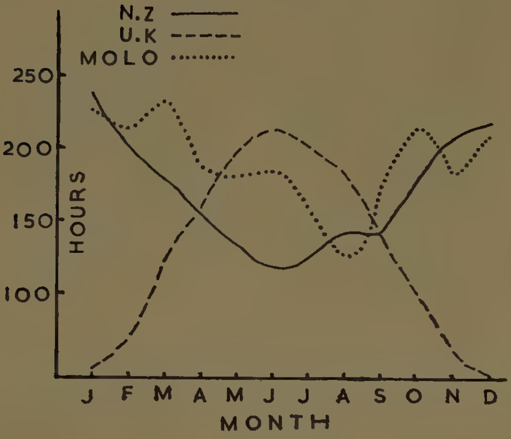
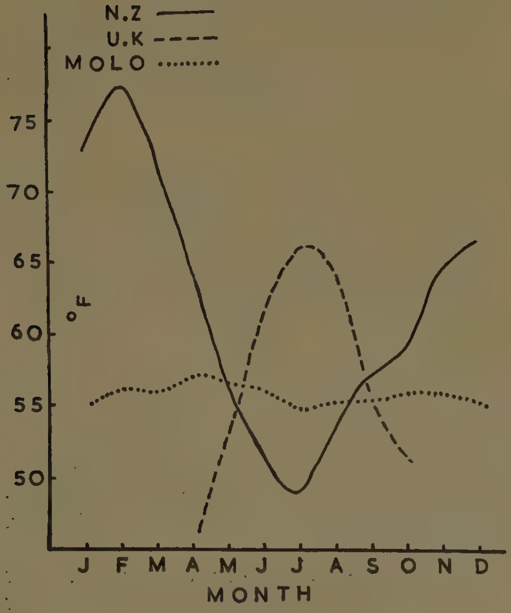


FIG 4

SOIL TEMPERATURES

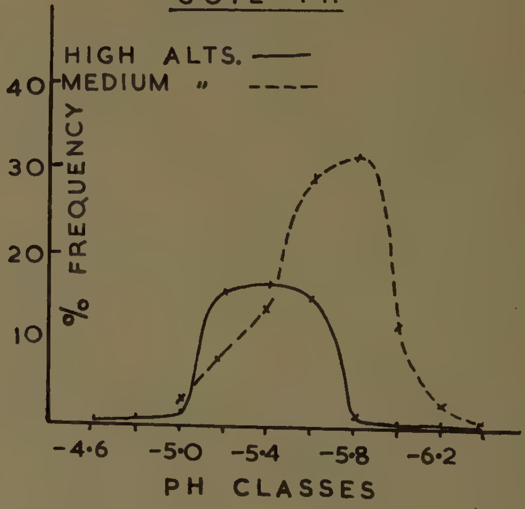


SOILS

No detailed description of the high altitude soils is attempted here. For advisory work, however, particularly in relation to the growth of exotic legumes such as lucerne and clovers, it is of some interest to see what the variation and range in soil pH and exchangeable calcium is in these soils. Extracts have been made, therefore, from all the known postwar soil analysis data in the Scott Agricultural Laboratories, and from the Highland Fertiliser Scheme [9] results. The frequency of samples from the high altitude Molo, Mau, Turi. Thompson's Falls, Ol Joro Orok and Kinangop areas which fall in various pH classes is shown in Fig. 5. Sixty-nine samples are involved. Over the range of pH 4.4 to 6.4 the frequencies approximate to a normal curve quite surprisingly, with a mean of 5.5 and a mode of 5.4. The regression of exchangeable calcium on pH is Y=5.95 X−25.08 (t=7.9. For P 0.001 t=3.6), for these samples where Y is exchangeable calcium and X is pH. As many of the samples were sent in by farmers the soils might reflect a bias towards the rather poorer soils on which advice was needed. This may be found to be so in the future when results of the detailed soil surveys, which are being undertaken by the Department of Agriculture, are published. Meanwhile, on the basis of the above figures and on general experience, it is considered a safe generalization that at least half the arable soils at the high altitudes lie within a 5.0 to 5.6 pH range, and about 70

FIG 5

SOIL PH



per cent within the 4.8 to 5.8 range. By conventional standards these soils are fairly acid. The pH of 105 samples [9] from the medium altitude soils which cover a far wider range of soil types than the above have a mean of 5.6 and a mode of 5.8, the curve being somewhat skewed. This mean is only 0.1 unit more than that of the high altitude soils, but the modal value is 0.4 units greater. The regression of exchangeable calcium on pH is $Y=5.99\,X-24.81$ ($t=8.9$. For P 0.001 $t=3.4$) being very similar to that of the high altitude soils. It may be concluded from this rough comparison that the high altitude soils are more acid than those lower down.

In Table II are shown the analyses of a few specific examples of the arable high altitude soils for comparison with the arable soils on the Grassland station which are markedly base deficient, with base saturations of 30 to 40 per cent, and a pH range of 4.9 to 5.5.

DISCUSSION

The data shows that the high altitude Kenya climate is of an intermediate type being neither as cold during the winter rainy season nor as hot during the dry summer weather as is the typical winter rainfall climate of South Australia. Compared with temperate countries, temperatures are equivalent to, and never higher than, those of the late English spring or early autumn. Until evaporation data are available there is little point in attempting a more precise definition, but pasture observations indicate that soil moisture may limit growth for four months of the year. The climate is, however, nearly unique in its altitude, temperature and day length conditions; the only other place comparable being a small mountainous area on the Equator near Quito, in Ecuador.

The effect of the high altitude climate on the growth and behaviour of ley species can be marked. For example, the indigenous medium altitude grasses such as Rhodes, Molasses, and Guinea, grow slowly, presumable because temperatures are not high enough. There is, however, scope for selection among the species of Setaria some of which grow naturally at a higher altitude than the other species mentioned. The natural grass flora above 8,000 ft. is poor, the commonest species being *Themeda triandra, Pennisetum Schimperi, Eleusine jaegeri, Exotheca abyssinica, Eulalia polyneura, Andropogon* spp. *Eragrostis* spp. *Digitaria* spp., and, in heavily grazed areas, kikuyu grass. None of these, except kikuyu grass for the longer leys, is likely to be of any use for sown leys, and so the only fields for exploration for grasses which grow naturally under our exact climatic conditions are the East African high mountains, and those of Ecuador. As these have not, so far as I know, been explored (in the agronomic sense of the word), there has been no option but to use ley grasses from the temperate zones. Mitchell [10] has, from controlled environment studies, stated that the optimum temperature for the temperate grasses is around 55 to 65 deg. Fahr. which is within our local temperate

TABLE II.—HIGH ALTITUDE SOILS (ARABLE LAND)

DESCRIPTION				EXCHANGEABLE BASES, m.e./100 g SOIL					
	%N	%C	pH	Total capa-city	Total	% Satura-tion	Exch. Ca.	Exch. Mg.	Exch. K.
Molo G.R.S. Virgin Land	0·31	4·3	5·3	28·3	8·7	30·7	5·5	2·5	1·4
Molo G.R.S. Virgin Land	0·36	3·9	5·6	30·5	13·5	44·3	9·6	3·2	2·0
Molo Reverted Old Arable	0·31	3·5	5·1	26·8	8·4	31·4	5·5	2·0	2·4
Molo Old Arable	0·32	3·5	5·1	28·5	9·5	33·4	6·4	1·6	2·2
Molo Old Arable	0·31	3·5	4·9	28·9	8·1	28·0	5·5	1·5	2·0
Lee's farm N. Kinangop Arable	0·26	2·9	5·2	14·7	8·1	55·0	5·4	1·5	0·6
Nimmo's farm N. Kinangop Arable	0·51	5·3	4·8	31·9	13·0	41·0	8·9	2·0	1·2
Hemphill's farm Mau Summit Arable	0·31	4·0	5·4	23·5	11·8	50·0	6·7	2·5	1·5
Marindas farm Molo Arable	0·36	3·7	5·5	29·6	17·7	60·0	10·3	2·6	2·6
Ryan's farm Molo Arable	0·39	3·9	5·4	26·5	13·6	51·0	8·3	1·9	2·5
Knagg's farm Mau Summit Arable	0·24	2·7	4·9	20·8	8·7	42·0	4·9	1·4	1·6
Swindlehurst's farm Mau Narok Arable ..	0·51	5·0	5·9	—	19·6	67·0	12·1	5·0	2·2
Swindlehurst's farm Mau Narok Arable ..	0·50	4·6	5·8	—	16·6	62·0	10·0	4·8	1·6
HIGHLAND FERTILISER SCHEME. (REF. 9)									
Mean of 17 High Alt. Arable Soils	0·34	3·8	5·3	22·2	11·7	53·0	7·5	2·1	1·6
Range { 17 High Alt. Arable Soils—Highest figure	0·61	5·6	6·1	30·8	21·4	81·0	14·2	4·1	2·8
Range { 17 High Alt. Arable Soils—Lowest figure	0·22	2·5	4·9	11·6	4·8	41·0	3·3	0·6	0·5

range; he found the optimum for *Paspalum dilatatum* to be 85 deg. Fahr., and the very slow and poor growth of this grass at Molo is entirely in accord with his observations. These temperate grasses are, however, long-day plants and it is a debatable point whether dry matter production from these may not be considerably less locally than in their countries of origin in the higher altitudes, other limiting factors being equal. It is possible, however, that the greater insolation on the Equator, when the sun is shining, may compensate for the shorter days. The flowering of temperate species is, of course, profoundly affected by day length and temperature and most of the importations flower poorly, if at all, at Molo [11]. This can have far-reaching effects on the management of sown pastures, and the farmer can be in the fortunate position of never needing to mow leys to control stemminess. Seed production, however, is out of the question with many strains of these imported temperate grasses.

Turning now to the effects of climate on legumes, the indigenous Kenya white clover (*Trifolium semipilosum*), which is the most promising clover for the medium altitudes, grows poorly at Molo compared with *Trifolium repens* and is clearly unsuited to the local climate and soil conditions. However, this clover grows abundantly at high altitudes East of the Rift Valley. The converse would seem true for *Trifolium semipilosum* var. *kilimanjaricum* and *Trifolium burchellianum* var. *johnstonii*, both of which grow abundantly West, but not so, East of the Rift Valley. It is not possible to say at present whether this curious distribution is due to soil and climatic factors, or whether it is due to accidents of dispersal caused by the recent, in the ecological sense, disturbance of the ecology of the high altitudes by intensive agriculture. Of temperate clovers Mitchell [10] has given 75 deg. Fahr. as the optimum for New Zealand white clover *Trifolium repens*, so it is likely that the high altitudes are too cold for optimum growth of this plant (it will be recalled that even mean maximum temperatures do not exceed 65 deg. Fahr. at the high altitudes). It is, furthermore, well known in temperate climates that the grasses grow away in spring before the clovers, the period of main clover growth being in summer. It is also well known that nodulation is affected by carbohydrate synthesis and balance, and it might be expected, therefore, that both day-length and temperature would be important in their effects on nodulation and nitrogen fixation. In an extremely neglected field of research Young [12] has shown that, as might be expected, the most important factor governing the total number of large nodules under a white clover/grass sward in England was the amount of clover root material present. Furthermore the number of large nodules reached a peak at midsummer. This peak coincided with long and warm days. It has also been shown [13, 14] that Soya beans under a 16-hour day produced about 12 times as many nodules which were ten times heavier than those produced under an eight hour day. One might therefore expect nodulation under a 12-hour day to be considerably less than that under long days, and especially so, if long-day species are used.

On these grounds, and also because of the susceptibility of *Trifolium repens* to drought, it is at present an open question whether other legumes more suited to the climate should not be used at the high altitudes. The other legumes of most promise are subterranean clover and lucerne. The former is a winter growing annual with temperature optimums of 55 to 65 deg. Fahr. (Mitchell [10]). More recent Australian work has shown that the strains of this clover have different temperature needs for optimum growth, the Bacchus Marsh strain being the least demanding in this respect; it is of interest that this strain is the most vigorous at Molo. The season to season regeneration of the subterranean clovers has, however, been found to be poor (unless sown in a pure stand), regeneration being affected by insect damage to the seed and by abortive germinations in the dry weather when the showers which are enough to germinate the seed are not sufficiently prolonged to establish the seedlings. Notwithstanding, as subterranean clover is clearly suited to the local climate it will be a useful legume for two-year leys on our acid soils. Finally, the legume with the longest growing season of all, and with the widest range of adaptation, is lucerne, This is grown at altitudes of over 10,000 ft. in South America and there is little doubt that it could be extensively grown at high altitudes in Kenya.

By conventional standards the high altitude soils are acid and are deficient in exchangeable bases, and it is surprising that legumes will grow as well as they do on soils of around pH 5.2 with base saturations of 30-40 per cent. This is probably a climatic effect since temperate experience suggests that crops will grow on more acid soils than usual provided that temperatures are not high. Comparatively low soil temperatures will, however, profoundly affect the uptake of those minerals needed by the grazing animal.

SUMMARY

For five to six months out of a growing season of eight months, when rainfall is not a limiting factor for pasture growth, the mean monthly temperatures at high altitudes (over 8,000 ft.) are considerably lower than those of the temperate and winter rainfall climates of higher latitudes. Kenya high altitude temperatures are similar to those of the spring and autumn of pasture countries such as New Zealand, England, and South Australia. The implications of this, the short days, the comparatively low soil temperatures, and the low pH of high altitude soils is discussed in relation to the need for ley grasses and legumes for the high altitude areas of Kenya, which total about 700,000 acres.

ACKNOWLEDGMENT

I am grateful to Mr. F. E. Rixon of the Survey Department for estimating the acreage of high altitude land.

REFERENCES

[1] Annual Report (1950). Department of Agriculture, Kenya.

[2] Private Communications, E.A. Statistical Department. (Agricultural Census 1957 and 1958.)

[3] *The Calculation of Irrigation Need* (1954), H.M.S.O., London.

[4] Climate, Robertson, N. G. *Science in New Zealand*, A. H. Reed & Co. (1957), Wellington, New Zealand.

[5] Geiger, R. (1957). *The Climate Near the Ground*, Harvard U. Press.

[6] Annual Report (1953) Department of Agriculture, Kenya. II.

[7] Private Communications, Rukuhia Research Station, New Zealand.

[8] Eggleton, W. G. E. (1934). *J. agric. Sci. 24*, 417-434.

[9] Holme, R. V. and Sherwood, E. G. P. (1954). *The Fertiliser Requirements of the Kenya Highlands*, H.M.S.O., London.

[10] Mitchell, K. J. (1956). *Proc. 7th Int. Grass. Congr.* 58-67.

[11] Birch, W. R. (1958). *E. Afr. agric. J. 24*, 142-147.

[12] Young, D. J. B. (1958). *J. Brit. Grassl. Soc. 13*, 106-114.

[13] Bonnier, C. and Sironval, C. (1956). *Nature 177*, 93.

[14] Sironval, C. and Bonnier, C. (1958). *Nature 181*, 1272.

REVIEW

REPRODUCTIVE PHYSIOLOGY, by A. Nalbandov, published by W. H. Freeman and Co., San Francisco, 1958, 271 pp., price $6.75.

This book presents in a most readable form a rather comprehensive survey, based largely on experimental observations, of the reproductive physiology of man, the common domestic and laboratory animals and birds, starting with a chapter on the biology of sex, and ending 12 chapters later with a discussion on some anatomical and physiological aberrations and abnormalities associated with reduced fertility and sterility.

It is obvious that with such a wide scope a book of this size cannot go into very great detail. Nevertheless, a reasonably clear picture emerges of—"the ultimate aim if not the reason for being of all organisms"—but at the same time many of the difficulties and inconsistencies of present-day knowledge are objectively presented and discussed.

Based on lectures given to students of such diverse disciplines as veterinary and human medicine, agriculture, nutrition, physiology and zoology, the book aims at and achieves the development of an appreciation of the inter-relationships of structure and function, and the chain of events which go to make up the normal reproductive process of a range of animals. In the light of this knowledge some of the ways in which the process may break down are discussed. Such ancillary information on anatomy, histology and embryology as is necessary to develop the main theme is clearly and concisely presented at appropriate points.

A notable feature is the brief summary at the end of each chapter, and also an up-to-date list of references, mainly to review articles and advanced textbooks, to which the more enquiring reader is likely to be stimulated to turn for further information.

If only as an antidote to the all too common specialization, this book should be read by those whose main concern is with the reproductive processes of only one or other of the common mammals, including man, and birds. It will provide a broad basis of understanding for all who have more than a passing interest in this most important branch of physiology.

G.D.P.

THE CULTURE OF TILAPIA NIGRA (Günther) IN PONDS

I. GROWTH AFTER MATURITY IN MALE T. NIGRA

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(*Received for publication on 15th April, 1959*)

Fish cultural research at the Inland Research Station of this Ministry, at Sagana, has been concentrated mainly on the factors affecting the growth of *T. nigra* under controlled pond conditions.

Owing to the ease with which this species can be sexed externally at all sizes down to 5 cm., and the marked sexual dimorphism shown by the greater growth of males as compared with females, *T. nigra* lends itself admirably to the monosex culture of males only (Brown and van Someren, 1953). Not only is monosex culture an economic technique, but it is also a valuable research tool, in that pond populations can be stabilized as to numbers, and hence the various factors affecting growth can be more easily studied without complications due to uncontrolled breeding increase.

As with other species of *Tilapia* (and indeed most other species of fish), the growth curve in *T. nigra* shows a steep rise in the first three or four months of life after liberation of fry from the parent female, which then gradually decreases until any further increase in length almost ceases, the curve becoming asymptotic.

With a given food supply, the actual rate of growth of the individuals of a fixed population is most sensitive to the stocking rate of the fish, and hence the total biomass of fish which that food supply has to support. Within the first two or three months of life however, there also appears, with the stock at present under observation, to be a maximum possible growth rate of about 4-5 cm. per month at temperatures of 75-80° F. (24-26° C.), which cannot be exceeded, no matter to what extent the stocking rate is reduced (van Someren and Whitehead, 1959*b*). There is, moreover, almost certainly an optimum stocking rate at which this maximum is achieved, due possibly to the operation of ethological factors since *T. nigra* is a shoaling fish; this aspect is still under study.

Furthermore, the final size which *T. nigra* will attain under any given set of conditions appears to be determined by the biomass of fish in relation to both pond size and the food supply available, either separately or in conjunction. This size becomes progressively smaller as the stocking rate is increased, either simultaneously or on a successive time basis using males only, or as a result of population increase due to breeding (van Someren and Whitehead, *loc. cit.*), and perhaps also as the pond size is decreased.

Thus in mixed sex ponds where breeding is allowed unchecked, the stocking fish (P) will attain a certain maximum size which is in relation to the rate at which they have been planted and to the size of the pond; but the succeeding F generations will cease growing at a progressively smaller size until the total F generations are "runted", and at the same time the rate of growth of both the F and the P fish decrease as the biomass increases (van Someren, 1953).

Superimposed on this decrease of growth rate and of final size attained by each generation (or successive stocking) is the fact of sexual maturation, which in itself has been supposed to check growth (Vaas and Hofstede, 1952). It is, however, important to distinguish sexual maturation from the actual breeding activity consequent upon maturation. Thus in monosex ponds, isolated males will still mature, but cannot breed, and the same applies to isolated females which consequently cannot undergo a "brooding fast" when incubating fry or eggs.

In lightly stocked male monosex ponds (say at 100 fish per acre), males will first show maturation and breeding colouration at about four months old, at a length of about 18 cm., and will also undertake nest making even in the absence of females. In overstocked mixed sex ponds, males will show these features at a much smaller size, but since their growth rate has been depressed it is probable that such small fish showing maturation features may in fact be as old as the former isolated males, and that maturation is much more a function of age than of size. The relation of size to age is very variable and much affected by population density, and in an overstocked pond mature and breeding fish as small as 8-10 cm. are almost certainly as old as the 18 cm. fish which first show maturation under monosex conditions at that size. This point, together with the apparent coincidence of slowing growth rate with maturity is still being studied and it is possible that while a correlation may exist, the two are not necessarily cause and effect.

Nevertheless, it has generally been assumed that once the fish were mature, at whatever size, their potential for fast growth had virtually ceased and all previous monosex stockings had been undertaken deliberately with only immature fish, so as to take advantage of the fast pre-maturity part of the growth curve before growth was checked, as had been supposed, by the onset of maturation.

In order to test this procedure further, the experiment described below was undertaken, and from the results it is now apparent that fast growth potential is almost as great after maturation as before; that so-called runted fish of a F generation still have a fast growth potential at least as great as that of their parents even after maturation; and that fast growth can still occur to a marked extent even after apparent cessation of all growth. These are findings of the greatest importance in the practical use of monosex as an economic technique.

From a half-acre pond which had been stocked with a few varying sized fish of each sex some six month previously, and which had since bred prolifically, 29 male fish were netted out in September, 1958, and marked with individually numbered plastic tags (van Someren and Whitehead, 1959*a*). These fish varied in total length from 7.9 cm. to 26.5 cm., those up to 15 cm. being almost certainly F generation fish, and those above this size being the P stocking fish which had grown well before breeding greatly increased the population density. Almost everyone of these fish from 8 cm. upwards were mature by the criterion of external colouration, and almost certainly all the P fish had bred at least once.

These were all returned to the original stock pond after marking and measuring, and their growth measured monthly for three months thereafter, under these overstocked conditions. In the third month 23 of these marked fish covering a range of sizes from 12.5-25.9 cm. and all, fully mature by external examination, were transferred to a virgin ¼-acre pond, thus giving a much reduced stocking rate of 92 per acre in the new conditions. The remaining marked fish were left in the stock pond as controls.

TABLE I.—GROWTH AFTER MATURITY IN MALE *T. nigra*.

Fish No.	Months after marking	Length (cm.)		Weight (gm.)		I.G.R. %		Remarks
		Total	Increase	Total	Increase	Length	Weight	
393	On marking	8·7	—	12	—	—	—	
	1	10·4	1·7	23	11	14·9	65·1	Overstocked conditions.
	2	11·8	1·4	30	7	12·6	26·6	
	3	12·5	0·7	35	5	6·8	15·4	
	4	16·8	4·3	85	50	29·6	88·7	Reduced stocking.
	5	18·9	2·1	115	30	11·8	30·2	
376	On marking	12·9	—	38	—	—	—	
	1	14·9	2·0	60	22	14·4	45·7	Overstocked conditions.
	2	16·1	1·2	75	15	7·7	22·3	
	3	17·0	0·9	85	10	5·4	12·5	
	4	20·9	3·9	160	75	20·7	63·3	Reduced stocking.
	5	22·7	1·8	200	40	8·3	22·3	
381	On marking	25·2	—	280	—	—	—	
	1	25·8	0·6	300	20	2·4	6·8	Overstocked conditions.
	2	25·8	0·0	300	0	0·0	0·0	
	3	25·9	0·1	310	10	0·4	3·3	
	4	28·1	2·2	370	60	8·2	17·7	Reduced stocking.
	5	29·7	1·6	465	95	5·5	22·9	
395	On marking	8·5	—	10	—	—	—	Controls, not transferred.
	5	13·4	—	45	—	—	—	
387	On marking	11·4	—	25	—	—	—	
	1	12·9	—	40	—	—	—	
	5	17·1	—	85	—	—	—	
379	On marking	26·5	—	315	—	—	—	
	5	27·0	—	325	—	—	—	

NOTES.—Nos. 393, 376 and 381 all mature on transference. Control fish all still mature in 5th month. No records for control fish in months 1–4 except in No. 387.

Growth of the fish transferred was followed monthly for another two months, the control fish also being remeasured in the fifth month. Subsequently six of the fish grown at the reduced stocking rate were replaced in the stock pond again and measured again at monthly intervals.

All the mature males transferred to the new pond at the reduced rate showed a markedly increased growth after transfer, the pattern being essentially similar in each one. The history of three of these fish, covering a typical range of sizes, is detailed in Table I, compared with three fish of similar size which remained as controls in the stock pond.

The control fish Nos. 395, 387 and 379, showed the much reduced growth rate characteristic of overstocked conditions, increments varying from 4.9 cm. in the smallest to 0.5 cm. in the largest, in the five months. The fish transferred, Nos. 393, 376 and 381 showed much increased growth in the new conditions, increments varying from 6.4 cm. for the smallest to 3.8 cm. for the largest in the two months of improved growth. The fish have not been individually weighed, the weights recorded being those calculated from a generalized weight/length curve already constructed for male *T. nigra* in monosex culture.

The results are shown graphically in Figs. 1, 2 and 3 for the fish which were transferred. From Fig. 1, it is evident that the two smallest fish were slowing in growth rate already in the stock pond as they neared the maximum size for their group, and the largest had virtually ceased growing, its larger size being due to the fact it was a P fish. It is most unlikely that the two smaller fish (both of which were clearly F fish), would have reached the size of the largest, as indeed is indicated by the lengths at five months after marking of the control fish of similar size.

Increased growth of fish on transfer, even though all were fully mature, is thus apparent; but it is also evident that even in the second month after transfer the growth rate of all three is beginning to slow after the initial impetus, as would be expected from the increasing biomass in the new pond. On superficial examination of the curves it might also appear that the new rate of growth for all three was very similar. However, this is not so, as is shown by the more true picture of growth rate which is obtained by transformation of the simple length growth shown in Fig. 1 to an instantaneous or geometric growth rate represented as a percentage per month in Fig. 2., which is derived from the formula

$$\frac{\log_e Yt - \log_e Yt'}{t} \times 100,$$

where Y is the length at times t and t′, t in this case being one month, and t being later than t′.

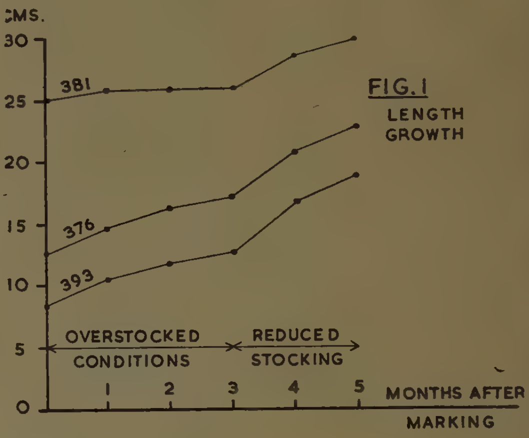

FIG. 1
LENGTH GROWTH

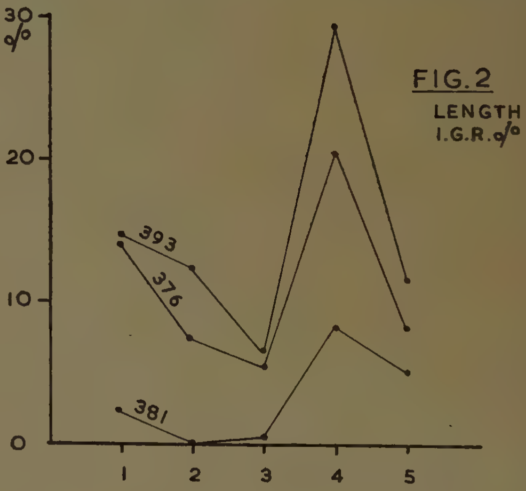

FIG. 2
LENGTH I.G.R.%

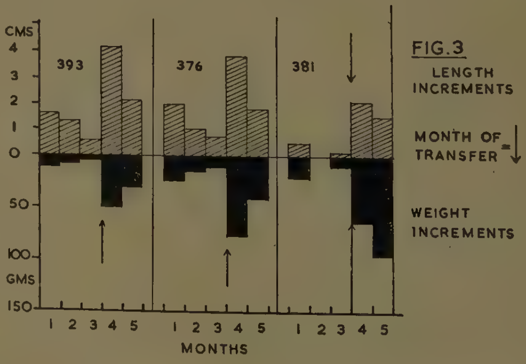

FIG. 3

Such instantaneous growth rate figures are strictly comparable from fish to fish at any month, and from these it is clear that the fish after transference grew at an increasing rate with decreasing size at transfer, a trend which is also shown for the instantaneous growth rate for weights, for the first month. For the second month, although the two smaller fish still had a faster growth rate than the largest, their rate of growth had actually fallen to a lower level than when they were first marked in the stock pond, whereas the largest fish still maintained an instantaneous growth rate higher than at first marking. Thus the smaller the fish on transfer, the greater the percentage decrease in growth rate.

The results shown in Fig. 3 are even more striking, since they show that while actual length increments per month decrease in magnitude with increasing size of fish on transfer, nevertheless the weight increments which these length increments represent increase at a higher rate the larger the fish is on transfer. Such a result can be expected since the length/weight relationship is logarithmic.

Thus in terms of actual weight obtained (which is of immediate practical interest) it is more advantageous to transfer the bigger fish to improved conditions. Even though all fish may be fully mature on transfer a greater growth potential for weight still exists in fish as large as 26 cm., although length growth may have apparently ceased sometime previously. It is equally obvious that there must be some upper limit to the size at which fish can still take advantage of improved conditions, and this aspect is still under investigation.

The graphs show the results for only two months after transferring these three fish. Two of these have been replaced in the stock pond, and as predicted, their growth has again ceased under the heavier stocking conditions within a month of replacement. Others remaining in the reduced stocking pond are still showing marked increments.

From the practical fish cultural point of view the advantages are obvious, and such a fattening procedure is clearly worth while. Thus males can be picked out from highly overstocked ponds with a runted population, and fattened further in monosex ponds at a reduced stocking rate, irrespective of their state of maturity and previous history of breeding. Within some limits, not yet defined, it is probable that males of 20-25 cm. will give the best yields from such a procedure. Evidence is now accumulating from other experiments in progress that, while competition, and hence depression of the growth rate and final size, may be intense in stockings of similar sized fish, it may be less so in stockings which consist of the same numbers of various sizes of fish. This is probably a reflection of changing feeding habits or food requirements as the fish attain successively larger sizes, since fish of similar size tend to shoal together and are thus immediately competitive with each other within the shoaling area. This aspect is of much importance in increasing the yields obtainable from fattening procedures which will involve repeated stockings of various sized fish.

These present findings will make the whole procedure of monosex culture very much easier. Thus, instead of sexing immature fish by the more time-consuming method of examination of external genitalia, and using only immature small males which have hitherto been considered to give the best yields, it is now possible from simple netting of an overstocked breeding pond to pick out and fatten only those males which are immediately recognisable as males from their colouration. Maturation colours in *nigra* males are quite distinctive, and colour differentiation of sexes is immeasurably quicker than inspection of genitalia.

Previous analyses of fish from overstocked ponds, and internal examination of several hundred F generation fish from each, have shown that the sex ratios of these fish show a slight preponderance in favour of males, which form some 55-60 per cent of the total population (van Someren, 1953), as they do in *T. mossambica* (Vaas and Hofstede, 1952). It remains now to determine with what frequency mature males can be netted from an overstocked pond and picked out on the basis of colouration only.

In this connexion aquarium experiments by the East African Fisheries Research Organization (E.A.F.R.O., 1959) have suggested that in *T. zillii* and *T. esculenta* only a limited number of males can show breeding colouration at any one time in a limited water area. Possibly the explanation is an ethological one, due to social dominance as in many other animals, and it seems most likely that a similar state of affairs prevails in an overstocked pond, the available breeding area in a pond bottom being parcelled out amongst only a limited number of sexually dominant males who in consequence show full breeding colours. The number of these is dependent on the area of pond bottom suitable for breeding, since *Tilapia* are highly territorial.

If such dominant males are removed for fattening it again seems probable that, within a short time, as in the aquarium experiments, their place will again be taken by an equivalent number of mature males who will develop the full breeding dress. These in turn can then be removed on the basis of colouration, leaving a few to breed further, and so on.

This aspect of management procedure is now under study, as is the question of optimum stocking density of various sized males to give optimum fattening within a limited time having regard to different survival rates at various stocking sizes. Evidence on the latter has so far suggested on broad lines that the larger the fish on transfer the better its chance of surviving over the fattening period, which accords well with the better weight growth attained by such fish. Results from tagged fish have already shown that their longevity is over 18 months, even in overstocked ponds.

The enhanced growth of mature males under improved monosex conditions is reflected in profound changes in the method of scale growth, and in the absolute size and spacing of the individual circuli. Since scale growth after a certain size appears in direct linear proportion to length growth of the whole fish, it is therefore possible to back-calculate length at transfer from direct measurement of the scale. This may lead to more exact age calculation techniques. Such altered scale growth and its interpretation is thus of fundamental importance, and the results will be considered elsewhere.

SUMMARY

Transference of mature or breeding male *Tilapia nigra* of various sizes from an overstocked pond, in which their growth rate had slowed or ceased, to another pond at a much reduced stocking rate, resulted in a marked increase in their subsequent growth.

Growth in weight of larger fish so transferred was in much greater proportion than that of the smaller fish.

These findings are of importance in the use of monosex culture of males as an economic technique, since it is much quicker to sex males by colouration only when mature, than by the examination of external genitalia when immature. It is no longer necessary to select immature males for culture, since even breeding males from a runted population can be fattened appreciably under reduced stocking. Transference of fish to improved conditions is accompanied by marked changes in scale structure.

REFERENCES

Brown, J. M., and Van Someren, V. D. (1953). New Fish Culture Methods for *Tilapia* in East Africa, *Nature, 172,* 330.

East African Fisheries Research Organization (1959). Annual Report, 1958, E.A. High Commission, Kenya.

Vaas, K. F., and Hofstede, A. E. (1952). Studies on *Tilapia mossambica* Peters in Indonesia, *Contr. Inl. Fish Res. St.* Bogor, *1,* 1.

Van Someren, V. D. (1953). In Review of Kenya Fisheries, 1952. Govt. Printer, Nairobi, 1953, 54.

Van Someren, V. D., and Whitehead, P. J. (1959*a*). Methods of Marking *Tilapia* spp. (Pisces: Cichlidae), *Nature,* 1959 (in press).

Van Someren, V. D., and Whitehead, P. J. (1959*b*). Unpublished results.

REVIEW

NUTRITION OF THE LEGUMES, edited by E. G. Hallsworth, published by Butterworths Scientific Publications, London, 1958, 359 pp., price 55*s*.

This is a record of the proceedings of the University of Nottingham Fifth Easter School in Agricultural Science, 1958. The 24 papers presented at the meeting are arranged in five groups: the plant component; the rhizobial component; the symbiotic system; biochemical aspects; and field aspects. A sixth section gives brief notes on eight demonstrations which were given in addition to the papers. Subjects, authors, and plant names are indexed.

The papers cover a wide field, and are of interest to agronomists, botanists, bacteriologists, and chemists, ranging from the growth of a clover sward to the classification of the rhizobia. Although only two of the papers deal specifically with legumes in tropical agriculture, the others are of great interest, and possibly of direct application, to tropical problems.

D.W.D.

PRELIMINARY INVESTIGATIONS ON THE EFFECT OF FERTILIZERS APPLIED TO NATURAL GRASSLAND

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It has been estimated by Troup [1] in his report on the farming economy and agricultural expansion of the Kenya Highlands, that nearly 2,000,000 acres, which is little less than two-thirds of the total acreage of the mixed farming areas, will remain as natural grassland. It is apparent from this that natural grassland will continue to provide the greater portion of grazing for animal production in these areas. With this in mind, we may well take the advice of Stapledon [2] who, discussing natural grassland in the United Kingdom, stated "we should be on the soundest of sound lines to assume that an animal needs browse and that he knows he does".

Boyd Orr [3], who was the first to study the use of fertilizers on natural grassland thirty years ago in Kenya, found, however, that the "browse" was seriously deficient in phosphorus and other universal nutrients. He concluded from investigations carried out in four districts that tillage of the ground together with the application of nitrogenous and phosphatic fertilizers greatly increased the productivity of the natural grassland. This result was not confirmed by Dougall [4], who considered that the initial improvement either of worn-out pastures or of rough grazing will not be brought about merely by top-dressing them with fertilizers. In his experience response to fertilizers measured in terms either of productivity or of nutritive value is far too slight to justify their use in most circumstances.

The results of the study reported here, however, show that substantial increases in yield of herbage can in fact be effected solely by applying nitrogenous and phosphatic fertilizers to previously uncultivated natural grassland.

The present experiment was prompted by results obtained from an observation trial carried out for two years on a neighbouring piece of seasonally wet natural grassland. The result of this trial showed that the mean dry matter yield from the plots which received sulphate of ammonia at 1 cwt. per acre and triple superphosphate at 1 cwt. per acre was increased by 23.19 cwt. per acre over the control yield, and similarly the yield from those which received 2 cwt. per acre of each of the fertilizers respectively was increased by 58.19 cwt. per acre over the control yield. The mean dry matter yield from plots which received 2 cwt. per acre of triple superphosphate was no better than that of the control plots without fertilizer. These results indicated that a substantial increase in yield of dry matter could be obtained from the application of sulphate of ammonia and triple superphosphate to the local natural grassland.

An investigation of the effect of fertilizers applied to natural grassland in the *Combretum-Hyparrhenia* zone was carried out on the Grassland Research Station at Kitale, with the object of determining whether the application of fertilizers could in fact bring about an increase in dry matter production and in the number of the more desirable grass species in the subclimax vegetation.

EXPERIMENTAL

A fertilizer experiment in the form of a $3 \times 3 \times 3$ factorial design with a single replication, carried out for three years, was started in 1954. The fertilizers used were sulphate of ammonia at 0, 2½ and 5 cwt. per acre, which was broadcast annually in split dressings during the growing season; triple superphosphate at 0, 1½ and 3 cwt. per acre broadcast at the beginning of each growing season, and sodium chloride at 0, 2½ and 5 cwt. per acre, broadcast at the beginning of each growing season.

At the beginning of the experiment all plots received an application of 1¼ cwt. per acre of muriate of potash, but this was not repeated in subsequent years.

The experiment was sited on typical natural grassland consisting mainly of *Hyparrhenia filipendula*, *Setaria* spp., *Loudetia kagerensis*, *Digitaria maitlandii*, and *Brachiaria* spp., which has been grazed and burnt periodically, but not managed according to any definite system.

Plots of eleven square yards were marked out in three blocks of nine plots per block. Herbage samples were taken from within a one square yard metal quadrat frame which was thrown at random within each plot. Eight herbage samples per plot were taken when the grasses had reached the early flowering stage of growth.

The material from each quadrat was weighed and a 2lb. sample from the bulk of eight samples per plot was taken for dry matter determination. After sampling, cattle grazed the plots and these latter were mown when grazing was completed.

Results

Fertilizer responses are expressed in hundredweights of dry matter per acre in Tables I and II. In Table I the 1954 and 1955 results are combined, as only two sample cuts were taken in 1954 but four in 1955. At the termination of the experiment a botanical analysis of each treatment was carried out, to determine the effect of the fertilizers on the change in the grass composition. The results of this analysis are presented in Tables III, IV and V.

Table I.—Main Effect and Interaction Totals, 1954 and 1955

Dry matter yields in cwt. per acre

Factor	Linear	Curvature	Factors	Total
NaCl	−13·33*	−0·45	NaCl^{1}P^1	−29·87
P	−9·33	−7·11	NaCl^{1}N^1	−7·33
N	+40·44***	−23·11*	P^{1}N^1	−12·67
S.E.	6·00	9·79		14·60

Table II.—Main Effect and Interaction Totals, 1956

Dry matter yields in cwt. per acre

Factor	Linear	Curvature	Factors	Total
NaCl	−5·16	−4·37	NaCl^{1}P^1	−7·98
P	+8·45*	−9·72	NaCl^{1}N^1	−12·00
N	+74·42***	+1·29	P^{1}N^1	+7·67
S.E.	3·38	5·75		9·33

Table III.—Influence of Fertilizers on the Percentage Loudetia Kagerensis in the Composition

Main Effect and Interaction Totals

Factor	Linear	Curvature	Factors	Total
NaCl	−30·5	−21·5	NaCl^{1}P^1	+17·0
P	−23·5	−4·0	NaCl^{1}N^1	+43·5*
N	−59·0*	+13·0	P^{1}N^1	+2·0
S.E.	24·55	42·53		20·05

Table IV.—Influence of Fertilizers on the Percentage of Setaria Spp. in the Total Composition

Main Effect and Interaction Totals

Factor	Linear	Curvature	Factors	Total
NaCl	−5·5	+62·5	NaCl^{1}P^1	+33·5
P	+10·5	+89·5	NaCl^{1}N^1	−13·0
N	+96·5**	+46·0	P^{1}N^1	−21·0
S.E.	28·3	48·06		23·13

Table V.—Influence of Fertilizers on the Percentage of Themeda Triandra in the Total Composition

Main Effect and Interaction Totals

Factor	Linear	Curvature	Factors	Total
NaCl	−12·0	−24·0	NaCl^{1}P^1	+0·5
P	+2·5	+7·5	NaCl^{1}N^1	−31·0*
N	−41·5*	−31·5	P^{1}N^1	−8·0
S.E.	16·58	28·74		13·54

From Table I and Table II it is apparent that sulphate of ammonia alone at the intermediate level of application, namely 2½ cwt. per acre, has given a highly significant increase in yield in both seasons. In the first season the higher application caused a depression in yield. It will also be seen that in the first year triple superphosphate at both rates of application did not produce any significant effect, but in the second year the intermediate application caused a significant increase in yield, while the higher application caused a depression, possibly due to an imbalance of nutrients caused by the heavier application.

It is interesting to note that there is no significant interaction between sulphate of ammonia and superphosphate under the conditions of this experiment, though by contrast it is generally accepted that for planted crops both fertilizers should be applied.

The effect of sodium chloride alone and combined with superphosphate and sulphate of ammonia was to reduce the yield of herbage. It seems therefore that there is no apparent lack of sodium or chlorine for plant growth generally under the conditions of this investigation.

At the termination of the experiment a botanical analysis was made of the grass species in each plot by means of a point quadrat. Two hundred points were recorded in each plot which, on an acre basis, is equivalent to 8,000 points. The effects of the fertilizers applied on three species, namely *Loudetia kagerensis, Setaria* spp. (*S. sphacelata, S. longiseta* and *S. trinervia*) and *Themeda triandra* are given in Tables III, IV and V. The fertilizers had no apparent effect on other grass species present. *Loudetia kagerensis* is a particularly undesirable species as it is relatively unpalatable and unproductive, and is one of the major co-dominant species in the composition. *Setaria sphacelata* is the most important of the three species mentioned and is one of the more palatable and productive components together with *Themeda triandra.*

It is apparent from Table III that sulphate of ammonia at the intermediate level of application caused a significant depression in the percentage of *L. kagerensis* but the combined effect of sodium chloride and sulphate of ammonia significantly increased the percentage.

Sulphate of ammonia only significantly affected the *Setaria* spp., the response is highly significant, but it is interesting to note that whereas the combined effect of sodium chloride and superphosphate is beneficial, the result is not statistically significant. Moreover, in the case of sodium chloride and superphosphate, the higher rate of fertilizer application has been more effective than the lower rate, as is shown in Table IV

The effect of the fertilizers on *Themeda triandra,* as shown in Table V, has been to reduce its percentage composition, and, in the case of sulphate of ammonia alone at the intermediate level and combined with sodium chloride, the reduction is significant.

From the three tables presented, it is apparent that each species of grass varies widely in its response to the fertilizers used. It may be that in the case of *Setaria sphacelata,* for example, this species can benefit from applications of sodium chloride and superphosphate applied at different rates of application to those used in this experiment, which may help to encourage the increase of this desirable species, although the effect of sulphate of ammonia alone is far greater than that of any other treatment.

DISCUSSION

It is apparent from the result of this field experiment that substantial increases in dry matter production can be achieved by the application of 2½ cwt. per acre of sulphate of ammonia. The main contribution to this increase was made by the *Setaria* spp. It is also apparent that triple superphosphate and sodium chloride are not necessary for increasing the production of herbage from the natural grassland at Kitale.

The influence of sulphate of ammonia on botanical composition was to reduce significantly the percentage composition of *Loudetia kagerensis* and *Themeda triandra,* but to increase significantly that of *Setaria* spp. Sodium chloride and sulphate of ammonia together effected a significant increase in the amount of *L. kagerensis,* but this treatment significantly depressed the percentage of *T. triandra.*

These findings can only be regarded as tentative until the long-term effect of the reaction of natural grassland to fertilizer applications can be investigated in detail.

REFERENCES

[1] Troup, L. G. (1953). Report on Farming Economy in the Kenya Highlands. Government Printer, Nairobi.

[2] Stapledon, Sir R. G. (1948). Conference on Grassland and Animal Health. *Nat. Vet. Med. Assoc. of Great Britain and Ireland, 1948.*

[3] Boyd Orr, J. (1931). Mineral Content of Natural Pastures, Sixth Report. H.M. Stationery Office, London.

[4] Dougall, H. W. (1954). *J. Brit. Grassl. Soc., 9,* 146.

A LAND USE MAP OF UGANDA

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In preparing suggestions for a possibly more complete national park and game management system in East Africa, it was found that there was no land use map of Uganda and that it would be necessary to prepare one. On this map are shown present national parks and game reserves. These areas are considered to represent distinct forms of land use which should be recognized more widely for their many values.

The preservation of native vegetation and wildlife has cultural and scientific significance and, especially in East Africa, great economic value. Game areas, as tourist attractions, may yield far greater financial returns to the nation than from any other use of those acreages. At the same time, they serve as living museums, maintaining examples of unique flora and fauna alive and in normally functioning communities.

National parks and similar areas dedicated to the preservation of natural conditions require lands which are (1) relatively natural and unspoiled by man's activities, (2) representative of the nation's major vegetation types and associated animal communities, (3) preferable of scenic and geological significance, and (4) in so far as possible made permanent (Petrides, 1955, 1958*a*). This last requirement is most important in view of rapidly increasing populations of humans and livestock, and ever-enlarging demands on water, minerals, wood, grass, soil and other resources. Game management lands devoted to sustained-yield production may also provide meat and recreation of considerable importance.

Permanent wildlife preservation in Africa is practical only on lands designated specifically for that purpose. This is true in part because the unique African wildlife is mostly big game and is destructive to crops and livestock. More fundamentally, the preservation of animal life cannot be accomplished apart from habitat preservation. Hence, even forestry or grazing, much less cultivation and industrial development, is inimical to the preservation of complete animal-plant communities.

As with the land use map for Kenya compiled earlier (Petrides, 1958*b*), the map presented here should not be considered to be a final product. It is presented only in the hope that its publication will encourage those with better facilities to compile a more complete and accurate edition. It is concerned only with primary uses of the land.

Some land uses in Uganda are now rather precisely mapped. The Forest Department, for example, has issued an undated map (possibly a portion of their annual report, 1958) showing administrative boundaries of forest reserves. I noted while in Uganda, however, that not all forest reserves had been set aside for timber preservation. Some areas of savannah and dry bush had been originally so designated (Chief Conservator of Forests, in conversation) apparently in efforts to protect watersheds or to direct settlement toward other areas. The principal rainforest timber reserves, therefore, are mapped here separately. Some small areas of both types had to be omitted because of the small scale of the land use map.

The Report of the Agricultural Producivity Committee (1954) contains a map outlining national parks, game reserves, and animal sanctuaries. Game reserves, and to a lesser extent national parks, are not completely closed to other land uses in Uganda, but they should be, and are here mapped as distinct forms of land use. The game reserve shown in the extreme north-east of the country has been newly gazetted. Since precise boundaries are not available, the area shown is approximate. Animal sanctuaries mostly were not mapped because of their usual temporary nature and superimposition on other land uses. The elephant sanctuary along the Nile is outlined, though, since, as a designated sleeping sickness area, it is presently closed to legal entry.

The areas of principal human use were the most difficult to map. Officials in each administrative district were asked to outline the areas of densest populations and most intensive cultivation. This was done during conferences,

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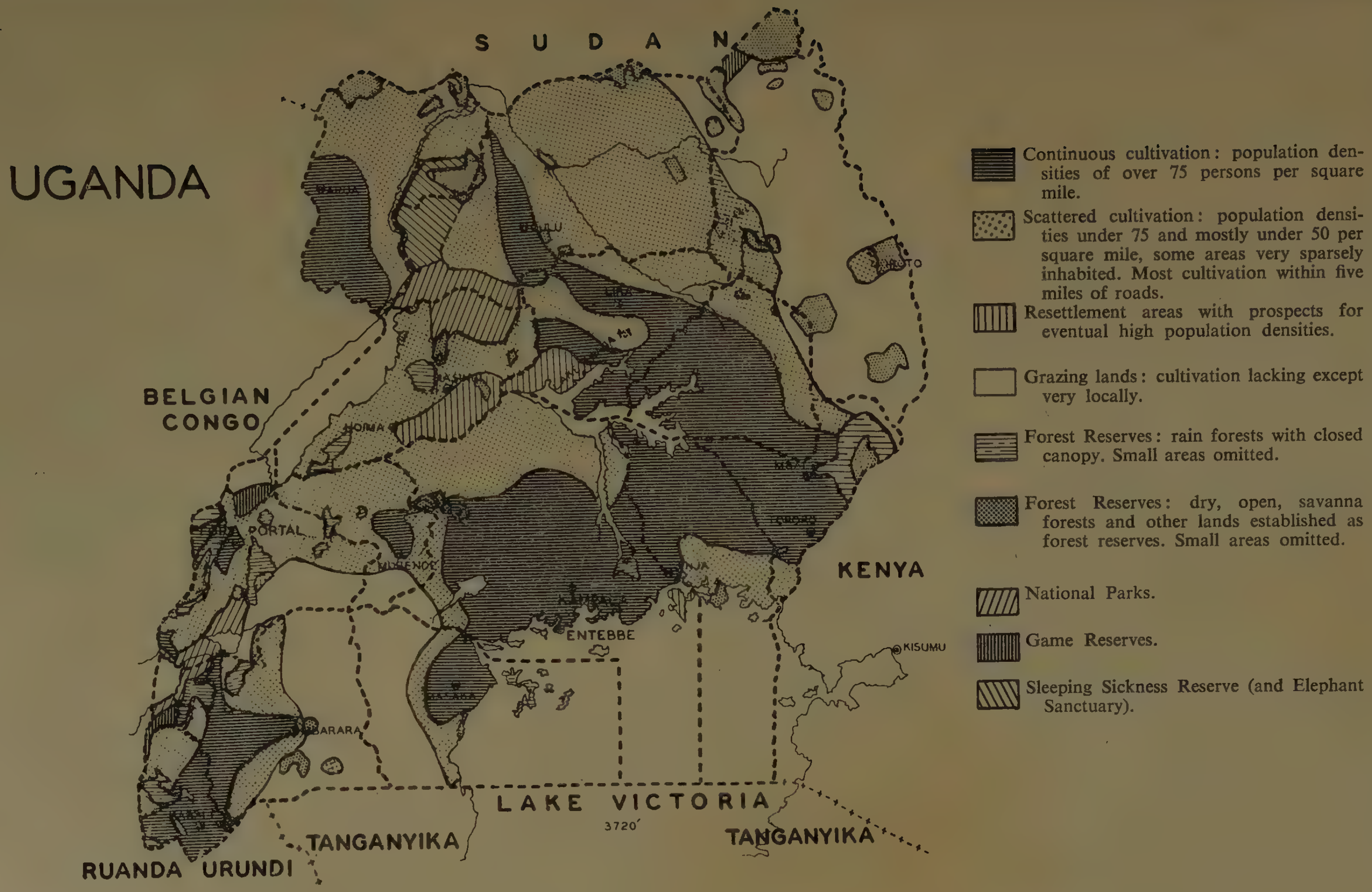
* Working under a Fulbright Research Grant with the Fauna Research Committee, National Parks, Game Department, and Virus Research Institute of Uganda.



▤ Continuous cultivation: population densities of over 75 persons per square mile.

▒ Scattered cultivation: population densities under 75 and mostly under 50 per square mile, some areas very sparsely inhabited. Most cultivation within five miles of roads.

▥ Resettlement areas with prospects for eventual high population densities.

☐ Grazing lands: cultivation lacking except very locally.

▤ Forest Reserves: rain forests with closed canopy. Small areas omitted.

▩ Forest Reserves: dry, open, savanna forests and other lands established as forest reserves. Small areas omitted.

▨ National Parks.

▥ Game Reserves.

▧ Sleeping Sickness Reserve (and Elephant Sanctuary).

using large scale district maps. Their designations were compared with my observations in travel about the country. Their boundaries were modified, also, according to maps of rainfall probability and potential crop production (Agric. Productivity Comm., 1954), and vegetation (Snowden, 1954). Tsetse fly distribution maps (Tsetse Control Dept., 1954) also were used since they yielded implications on the densities of vegetation, livestock, and humans. They also outlined major resettlement areas.

Tables of population density by districts (Colonial Office, 1957) were of some assistance in bounding the areas of heavy population density and more or less continuous cultivation. Large areas in Uganda, however, are developed to some extent only by scattered cultivation, mostly near roads. The back country is largely unoccupied. From the standpoint of game preservation it is important to separately map such sparsely-settled districts since they contain considerable wildlife. Game there frequently is heavily, even wastefully, hunted and the scattered settlers demand game control. This is ostensibly for crop protection though often actually for the meat produced. Areas for permanent managed game production are needed in such districts, since game ranching could be a practical and efficient method of animal husbandry. Game herds are otherwise doomed, since the future certainly will bring increasing cultivation and livestock grazing.

The open plains were of interest as offering the greatest potential for game preservation. The two major regions in Karamoja to the north-east and Ankole to the south-west are supplemented by an important plot westward on Lake Albert. Recommendations for new national parks and game production areas in these regions will be published elsewhere.

The map here presented has been reviewed by the offices of the Directors of Agriculture and Veterinary Services, of the Chief Conservator of Forests, and of the Game Warden, all in Uganda. They are not responsible, of course, for any errors involved. I am most grateful for their help and for that provided by many administrative, game, and veterinary officers. Dr. Wendell G. Swank of the Arizona Game and Fish Department, my colleague in ecological investigations in Uganda, assisted in most district enquiries. The base map used is one of those published by the Uganda Survey Department.

REFERENCES

Agricultural Productivity Committee, Uganda (1954). Report of the Agricultural Productivity Committee. Government Printer, Entebbe. 148 pp.

Colonial Office (1957). *Uganda 1956*. Her Majesty's Stationery Office, London. 162 pp.

Petrides, George A.—
(1955). Kenya's Wildlife Resource and the National Parks. Trustees, Royal National Parks of Kenya, Nairobi. 24 pp.
(1958*a*). Management of the Big Game Resource in Uganda, East Africa. *Trans. N.A. Wildlife Conf., 23*, 461–477.
(1958*b*). A Land Use Map of Kenya. *E.A. agric. J., 23*, 265–266.

Snowden, J. D. (1954). *The Grass Communities and Mountain Vegetation of Uganda*. Crown Agents for the Colonies, London, 94 pp.

Tsetse Control Department, Uganda (1954). Annual Report, Government Printer, Entebbe. 16 pp.

REVIEW

FARM WORK STUDY, by Nigel Harvey, published by Farmer and Stockbreeder Publications Ltd., London, 1958, 86 pp., price 8*s.* 6*d.*

The study of work by efficiency experts has been accepted in industry as a means of reducing production costs, and in this book the basic principles of the method have been applied to farm operations. Although the book is primarily intended for countries in which farm labour is expensive, it must be remembered that seemingly cheap labour can be extremely expensive if it is badly organized. In fact, it seems possible that work study applied to African labour might yield spectacular results.

The two chief factors involved in work study are the distance travelled in carrying out an operation and the "idle time", that is the time spent waiting during the operation. A detailed study of these factors is tedious to prepare and rather difficult to interpret, but much can be achieved by watching an operation to find its weaknesses. The value of the book to most farmers is to call their attention to the methods of work study: although they may not be prepared to undertake intensive studies they may be able to save time and money by simple application of the basic principles.

D.W.D.

THE BENA WATTLE SCHEME, NJOMBE DISTRICT, TANGANYIKA

By D. A. Nickol, Provincial Administration, Tanganyika

(*Received for publication on 12th February, 1959*)

The rolling mountain grasslands of Ubena, intersected by a network of little streams in deep valleys, and studded with relict clumps of rain forest, lie to the East of the Livingstone mountains and form a plateau the altitude of which varies from 6,000 to 7,500 feet. It is more like the Border country than tropical Africa and grey skies and cold weather add to the impression that this country is far removed from the Equator.

The Wabena, closely related to the Wahehe, live in scattered homesteads sited in the pockets of more fertile soil, some of which has retained a dark chocolate coloured top layer of volcanic ash windblown from Mount Rungwe. They graze their cattle and small stock on the downs and spurs which make up the greater part of the land. Red earths derived from granite and having very little humus in the top layer support a poor pasture, much of which is burnt off during the dry season. The principal food crops are maize, beans, peas, wheat and barley and though some of this is marketed the major cash crops are peas, sunflower seed and pyrethrum flowers. The Wabena themselves are intelligent, peaceable, not notably energetic as cultivators, are suspicion of new ideas until every avenue of doubt has been exhausted, and respond to the kind of gentle and patient leadership which their chief gives them.

In 1949 the Colonial Development Corporation was granted a lease of 44,000 acres of land in the centre of Ubena and with outstanding efficiency completed their development programme in seven years by raising 33,000 acres of Australian Black Wattle (*Acacia mollissima Wild*). The project is highly mechanized and uses a fleet of Caterpillar and Fordson tractors and heavy agricultural machinery all of which is very thoroughly maintained in their own workshops. The tannin extract factory which will treat the wattle bark from up to 55,000 acres has just been completed and will come into production in 1959.

In August, 1953, H.E. the Governor requested the General Manager of the C.D.C. wattle estates to draw up a memorandum setting out the broad principles under which the Wabena could be helped and encouraged to grow up to 20,000 acres of wattle and sell the bark to the Corporation factory. This was done, and the Native Authorities and people were consulted in a series of barazas throughout the chiefdom. These were successful, and with popular consent land was selected for wattle production in four out of the six sub-chiefdoms amounting to some 17,000 acres. The other two sub-chiefdoms came into the scheme a year later.

The basis upon which the Bena wattle scheme rests is that the C.D.C. ploughs, harrows and seeds the land for the people at cost and provides technical supervision. Two Government ex-patriate officers and a small indigenous staff administer the scheme and teach correct sylvicultural methods to the growers. The land is divided up into one-acre plots after the seed has germinated and these are allocated to the growers by the Great Commoners, who are village headmen, answerable to the sub-chiefs. The growers pay what they can afford towards the mechanical cultivation costs—Sh. 48 per acre—with a minimum of Sh. 10 per acre and the balance and capital and administrative costs are met by loans made from the reserve funds of the Territory's Native Treasuries—the Local Councils Board. So the land is held under customary tenure and the scheme rests firmly upon the Native Authority. However, it enjoys a great measure of autonomy in that the Bena Tribal Council has delegated to a Management Committee virtually all power to administer the project. This committee works extremely well. The District Commissioner is nominally chairman but has always delegated authority to his vice-chairman, the Chief. The Government officers and scheme staff attend the committee meetings but are its servants and executors, not its masters, nor are they members of the committee. It consists of 11 traditional rulers and commoners, all of whom are wattle-growers. It deals with all the business of administering the scheme in considerable detail, and controls expenditure by a close scrutiny of the accounts in August and December. In its fifth year it has been able to write the Estimates item by item in a one-day session.

Although the two ex-patriate Government officers and the indigenous staff do in fact run the scheme to a great extent—not forgetting that every change of policy must be made by the Management Committee—it is the relation of staff to committee members and growers as one of advisor and helper and not of master that is of fundamental importance. Every effort has been made to show the growers that the whole project is theirs, not only the land and the wattle trees on it but the office and equipment down to the ink and paper used in it. Most of the growers now understand this, and that all capital and administrative expenditure is being accumulated and charged interest and that the growers will be required to pay back the loans in full out of the first few years of bark harvests. The project is entirely self-supporting save for the two ex-patriate Government officers. Thus it could very easily be converted into a co-operative organization when the time is ripe.

Wattle matures in nine years in Ubena. The whole plantation in that age-group is then felled, the bark stripped off, the logs gathered in rows and the trash gathered over the lines of stumps and fired. As soon as it rains a second crop comes up with tremendous vigour and is stronger than the first in every respect. As far as is known regeneration can be carried out every nine years *ad infinitum*. Wattle, then, is a permanent crop yielding every nine years a harvest of about six tons of green bark per acre and more building poles and firewood than the growers will be able to use or carry away.

It follows that in order to secure a steady annual income and spread the work evenly each grower is encouraged to take up a plot (or plots) for nine consecutive years. Those who are doing this—and many are—will be sure of a regular income for life. The profit is not spectacular but it is attractive in relation to the amount of work put in; in the case of an absentee grower or one who is employed and relies on paid labour to carry out all weeding and thinning in the first four years, after deducting all costs except the cost of harvesting, the profit expected is about Sh. 615 per acre. This is detailed in Appendix "A". An income of Sh. 615 per year for growers who take up one acre per year for nine consecutive years will more than double the wealth of the great majority of Bena subsistence cultivators and have a correspondingly beneficial effect upon their standard of living.

A target of 20,000 acres has been mentioned. Table I shows what progress has been made towards this target to date (August 1958).

TABLE I

Age-Group of the Wattle	Target Figure	Acreage Developed
	acres	*acres*
1954/55 Coupe	500	503¾
1955/56 Coupe	1,500	1,576¾
1956/57 Coupe	2,000	2,599¼
1957/58 Coupe	2,000	2,402¼
1958/59 Coupe (*a*) ..	2,000	2,196¾
First five years ..	8,000	9,238¾

(*a*) Ploughed—To be harrowed and seeded December, 1958/January, 1959.

Having described the outline of the project and its main principles something must be said about the "life cycle" of wattle growing and how this is being done by the Wabena.

There are 26 wattle-growing centres administered by the scheme, and with minor exceptions where there is not sufficient land one ninth of the total acreage available at each centre is developed each year. Thus the steady growers who came into the scheme in the first year will end up with nine (or more) one-acre plots all in the centre closest to their homes and all in differing age groups.

The "life cycle" of wattle growing under the scheme follows this pattern:—

Two Years Before Seeding: A meeting of the local growers committee is attended by scheme and C.D.C. personnel to select the land to be tackled next in the unit concerned.

Scheme staff then mark it out with painted stakes and set out the firebreaks and roads of access. The local instructor then engages labour to stump out all trees and bushes and fill in any holes. Fire is excluded.

One Year Before Seeding: Towards the end of the rains the land is ploughed and remains to weather under frost and sun and drying winds until December when with the new rains it is harrowed.

Year One: Mechanical seeding takes place in January and is at once followed by survey into one-acre plots and these are allocated to the growers.

The growers then interplant food crops where the soil is sufficiently fertile and carry out line weeding. The lines of seedling wattles are then thinned down to clumps of from four to five plants 1 ft. 9 in. apart. Towards the end of the rains the weak plants are pulled out leaving only the best plant from each clump. A second weeding is sometimes necessary.

Year Two: During the rains a second year weeding is combined with a further thinning, reducing the spacing to 3 ft. 6 in. Some areas are inter-row cultivated with disc harrows and a second food crop is put in. Fire protection commences in the dry season.

Year Three: The plants are left at the 3 ft. 6 in. espacement, and although further inter-row disc cultivation is beneficial in most cases it is not essential as the trees at this stage are from 15 to 20 ft. in height and by partially shading the ground have begun to suppress the weed growth beneath them. Fire protection continues.

Year Four: The trees are then ready for the final thinning to give a 7 ft. espacement. This is done using axes and mattocks during the rains and the thinnings are useful poles as thick as your wrist and long enough for roofing huts. Fire protection continues.

Years Five to Eight: Fire protection only.

Year Nine: Felling and stripping followed by gathering the logs into windrows and firing the trash along the lines of the old stumps.

Year One—Second Rotation: A heavy line of germinated seedling develops along the lines over which there was a hot burn and the same weeding and thinning regime starts all over again. There is no further ploughing but inter-row disc harrowing becomes more essential than in the first rotation in order to aerate the top soil and keep the land clean between the rows of plants.

For the families which take up only one plot each year the work cannot be said to be heavy. However, it has been found that constant pressure by scheme staff and the village headmen has been necessary to get the growers to carry out the various operations in time. In fact the greatest failing has been the tendency for growers to leave weeding and thinning until dangerously late. Rather than let the wattle perish, or institute prosecutions in the local courts, the scheme staff has frequently engaged paid labour on behalf of the growers and debited their accounts with the cost plus interest plus an administrative charge.

The extent to which growers relied upon paid labour engaged on their behalf by the scheme became a matter for serious concern when in 1956 it amounted to a little less than a quarter of the whole task and in 1957 to rather more than one third. The United Nations Visiting Mission and senior Government officers commented adversely on this weakness and in 1958 the Bena Tribal Council decided that compulsion should be introduced after warning notices had been issued to each individual grower who had failed to tend his crop. This resolution was endorsed by the scheme management committee, by the local growers' committees and at numerous growers' meetings held throughout the country.

A few warning notices were issued and there was some improvement; there had been no prosecution during the 1958 weeding but the figures, when they are finalized, may not show much reduction since the Tribal Council made what are considered reasonable exceptions as follows: growers who reside more than four miles from the nearest wattle centre or who are in regular employment or who have a whole time business occupation may continue to receive assistance from the scheme in the form of paid labour working on their plots.

Large numbers of Wabena leave the district to work on sisal and tea estates and in other forms of employment. It might be said that these are the best of the young men in the tribe and it is certainly true that the great majority of those who reached either the top of the middle schools or who had secondary education are to be found outside the district today. Some deliberate effort has been made to reach these people and to encourage them to take up plots of wattle each year in order to have a stake in the land at home. Those who have responded to appeals made in the vernacular press and by two meetings held in Dar es Salaam and one in Iringa are absentee growers par excellence; their plots are looked after by the local instructors in every way and they are given a statement of their accounts annually.

At present there is little difference as far as the scheme staff is concerned between them and the larger numbers of local absentees—those living more than four miles from the centres and those in full employment at home. However, the difference will be brought into sharp focus when the first harvests begin, since the long-distance absentees will probably not be able to get harvesting leave every year or at the right time of the year.

The administration of a 20,000 acre scheme in which each plot is numbered and its sylvicultural progress is recorded task by task, year by year, must of necessity involve a great deal of accounting and recording work. The office staff has consisted of a Government Cashier on secondment and a cashier-cum-clerk from the local Native Treasury, both Wabena, but towards the end of 1957 it became necessary to engage a third man in the office. The manner in which the Accountant, accustomed to Government accounting procedure, and the Cashier, accustomed to Native Treasury procedure, have operated commercial accounts now running into some 4,000 individual accounts as well as the main ledger accounts deserves congratulation.

One instructor absconded with his month's takings, some Sh. 800, and was convicted of theft by a servant and his property was seized by the court to make good the loss. Another has been replaced on the grounds of lacking zeal but the present nine instructors are carrying out a heavy schedule of duties remarkably well. Not only do they perform the straightforward instructor function but they also have to act as collectors and payers and to supervise labour both on the plantations and on the roads of access.

The wattle is on the whole very well grown and is thought to be as good as the average C.D.C. wattle. This is due to the fact that much of the Bena wattle is sited on better soils than the C.D.C. land, some of which is poor, and not of course to better sylviculture or closer supervision. There are striking variations from plot to plot, demonstrating the value of early weeding and prompt thinning, and less obvious variations from centre to centre due to differences in soils. Fortunately the slower growth rate on poor soils is compensated for by the increased thickness in the bark. Tests carried out in the early part of 1958 on the oldest C.D.C. wattle, much of which was poorly grown on bad sites, have revealed weights of bark per tree which greatly surpass results in Kenya and this is due to the remarkable thickness of the bark at Njombe.

Pests and diseases have not presented any serious problem so far save for die-back, due to a deficiency of boron in the soil at one centre where development has now been halted. There was some damage from unusually severe frosts in mid-August in 1955. Couch grass is the greatest enemy, and its eridication by digging it out with fork-hoes, after ploughing and prior to seeding, is a very costly operation.

It has already been stated that the instructors and, when asked to assist, the village headmen, have to keep up constant pressure to persuade the growers to carry out weeding and thinning tasks in good time during the rains. The supervisory staff have also to put a good deal of pressure on the instructors to get what one might call the communal tasks done in time and within the estimated costs. These tasks are communal in that they have to be carried out by paid labour and the cost spread equally amongst all the growers in the centre concerned.

These are the so-called communal tasks and the cost per acre is shown opposite to each in Table II.

TABLE II

	Sh.
Stumping and clearing prior to ploughing ..	3/57
Couch grass eradication	–/60
Hand seeding—filling up the gaps	–/33
Survey and demarcation into one acre plots	–/80
Fire protection, but for a short period only..	–/51
Total cost per acre of communal tasks, 1954 to 1958	5/81

This figure may seem remarkably low—Sh. 5/81 per acre—for a total of five separate tasks. It is low at present and this is the result of pressure and supervision and constant checking, but it will undoubtedly rise as the cost of casual daily paid labour rises and interest is charged and fire protection continues for the full nine years. In Appendix "A", which indicates roughly the costs and the profit expected from an acre of wattle, these so-called communal tasks are shown as costing as much as Sh. 22 per acre at the end of nine years. This is an outside and a somewhat pessimistic figure but it has been made so deliberately for it is best to err on this side rather than on the other when discussing expected profits with the growers.

There is not space to describe in these notes the methods used to survey the land and later to divide it up into one acre plots. Suffice it to say that the survey is based on a grid of squares 70 yards by 70, and that triangular-shaped plots occur on the perimeter in order to follow the natural boundaries of the features. Right-angles are taken by using a prismatic optical square and distance along the base lines is measured with a brass wheel. An enormous amount of effort has been put into this work, always striving after a higher degree of accuracy.

Not very much thought has been given at this stage to the form which the wattle bark marketing will take, but such outline proposals as have been considered envisage a marketing organization operated by the scheme using its own tractors and trailers and engaging sufficient clerks to weigh all bark in the field. Bulk weighing would be carried out at the factory and payment made in bulk to the scheme, whose office staff would take on the task of arranging individual payments to the growers after deducting the share of the capital and overhead costs together with individual loans and interest charges.

It is expected that Government will supervise the price paid to the growers by the operation of a simple formula based on the current world price obtaining for wattle tannin extract.

These notes already carry some observations on the efficiency with which the Colonial Development Corporation staff at Njombe have carried out their own development and the manner in which they have ploughed, harrowed and seeded land for the Wabena at remarkably low costs. It has not, however, been sufficiently stressed that the very act of moving heavy agricultural tackle twice each year, and always during the wet season, to some 23 units scattered over steep mountainous country over a road system which though rapidly improving is still difficult enough, is in itself an achievement.

It is almost unnecessary to add, then, that this is not due to efficiency alone but to a measure of goodwill and generous help. The General Manager and his staff have at all times given the Bena Wattle scheme willing and devoted attention on a generous scale. This is well known and widely appreciated by the Wabena and it has had a beneficial effect upon relations between the Corporation and the Native Authority and his people.

It may sound presumptuous to end by regarding the scheme as successful so far as it has gone, for after all, the first harvest will not be gathered until 1963. However, it is suggested that the stage is set for a very fair measure of success and Government and the C.D.C. are determined that it shall come about, and there is no reason to think otherwise.

Accepting for the moment this optimistic view, it is interesting to discuss as a conclusion whether the pattern of the wattle scheme is a sound form of development and whether, with suitable adaptation this formula can be applied to other crops and other areas in the Territory. What are the fundamentals? What is the hypothesis?

In Ubena there was space enough for the large scale use of heavy machinery to develop some 33,000 acres of estate wattle and a further 20,000 acres of wattle individually owned.

There was an efficient and helpful corporation with a public spirited outlook firmly on the ground and with four years of experience.

There was a Native Authority and his people willing to give it a trial, even though there was a great deal of suspicion during the first three years, and having seen it start their enthusiasm grew with it.

Government backed it wholeheartedly and arranged for staff and funds for the first ten years.

Apart from two ex-patriate officers the scheme pays for itself and it is expected that all loans will be repaid from one rotation, i.e., when the last wattle sown is nine years old.

Commercial accounting and the engagement of professional auditors was accepted by all concerned without question.

By the establishment of the Management Committee and local growers' committees with very wide powers the scheme has been truly indigenous and is generally accepted as such amongst the Wabena themselves. Its nursing under the Native Authority patronage has been a vital factor in establishing this position.

A cash crop has been found which is comparatively easy to grow, is highly suited to the area and which will yield a good profit from poor land which has hitherto yielded very little indeed.

It is not suggested by any means that all or even the majority of these factors should be present before a scheme of this nature is launched, but some of them are inescapable necessities. It is open to argument whether the corporation role could be played by a corporation or even a limited company which was not itself an estate owner and was not profit making but was solely there to manage the indigenous scheme. There are examples of this form which have been highly successful.

APPENDIX "A"

THE ROUGH ECONOMICS OF WATTLE UNDER THE SCHEME

Cost of production	*Cost per acre*
Mechanical cultivation	Sh. 48
Stumping, survey, fire protection plus interest over 9 years, about	Sh. 22
Weeding and thinning (absentees) over 9 years, plus interest	Sh. 20
Interest on loans towards mechanical cultivation; average might be	Sh. 15
Total direct costs over 9 years	Sh. 105
Share of capital and overheads (*c.*)	Sh. 80
	Sh. 185
Nett income from 1 acre (bark) (*c.*) (transport deducted)	Sh. 800
Profit expected from 1 acre over nine years	Sh. 615

No allowance has been made for the labour in harvesting which it is hoped will be undertaken by the family without any paid labour assistance. The amount of work involved is estimated at 30 man/days for felling and stripping but might well rise to as much as 80 man/days including disposing of the trash, brushwood and logs under little supervision.

A profit of Sh. 615 per acre over nine years is not spectacular—less than Sh. 70 per acre per annum—but in relation to the amount of work involved, very light indeed for six out of the nine years—it offers an attractive return.

The profit expected from the second rotation is much more attractive since there is considerably less cost in production and the yield is heavier.

REVIEW

FARM ORGANIZATION AND MANAGEMENT, by G. Hayes, published by Crosby Lockwood and Son Ltd., London, 1959, 328 pp., 61 tables and nine diagrams, price 25*s.*

Books such as this, which are concerned with the organization and management of United Kingdom farms, might seem to have little interest to farmers in the tropics or subtropics. But organization and management are not subjects which depend on geographical position. They are of importance to every farmer wherever he is, and, while they may require intelligent translation in order to relate to local conditions, they are worth studying if only to see what one is up against in the export markets. Most of the subjects mentioned in this book, such as temperate cereals, roots, cattle, sheep, pigs, and poultry are all farmed in the Kenya Highlands so they are worth considering, if only to find out what the other man is doing.

The book is largely concerned with organization. The author points out that the farmer is often a good manager but is not necessarily a good organizer: hence he does not always achieve the maximum income from his efforts. No panacea is recommended. Instead, the author first examines the general agricultural background to farm organization in England and in doing so provides a succinct review of the various agricultural acts of the post-war period in England. He then passes on to consider details of wages, mechanization, capital requirements and the various means by which farming can be financed and the organization problems of different enterprises. The chapters on the different enterprises refer to the production of various crops, milk, beef, sheep, pigs and poultry and each contains up-to-date (often 1958/9) tables of costs of foods or production as a whole. For example, under pigs and poultry, he gives item by item the 1958/59 cost of a standard ration for a pig in England and in addition shows the cost of production to weaner or bacon weight. Of course these costs are United Kingdom costs. Nevertheless, they provide standards with which to compare local costs. For those who require greater detail there are up-to-date references at the end of every chapter, which provide a guide to further reading.

The book can be recommended to many farmers and agricultural students.

J.G.

LESSONS GAINED FROM GRAZING TRIALS AT MAKAVETE, KENYA

By H. C. Pereira, East African Agriculture and Forestry Research Organization, Muguga, Kenya, in co-operation with the Kenya Department of Agriculture

(*Received for publication on 6th May, 1959*)

A ten-year study of the restoration of overgrazed thorn scrub country in the Ukamba African Land Unit near Machakos was concluded in 1957. The field work was carried out by the Department of Agriculture with the assistance of E.A.A.F.R.O., the latter being responsible for continuity, particularly during the difficult Emergency years, and for the analysis of the large volume of data obtained. The study involved the testing of stock-carrying capacity of the countryside under intensive grazing management, comparing bush clearing and resting with more expensive agricultural treatments such as ploughing and re-seeding.

Forty half-acre paddocks were grazed for seven years—another forty were grazed for four years and were then ploughed up to assess residual fertility by a series of trials with cereals and bean crops. The object of the experiments was to obtain factual information on the productivity of this severely eroded and mismanaged countryside under intensive but realistic management conditions.

The establishment phase of the study during the years 1948 to 1951 was fully reported by Pereira and Beckley (1952). The productivity assessment over the years 1952 to 1957 inclusive is fully reported by Pereira, Thomas and Hosegood (1959). The present paper is a brief summary of the main lessons learned from the study.

THE PROBLEM

The higher altitude Machakos area of the Ukamba District (4,500 to 5,500 feet above sea level) has carried increasingly heavy concentrations of both human and stock populations during the past 30 years. The soils in the main consist of sandy, red basement complex loams which are readily erodable. Severe sheet and gully erosion and invasion of thorn scrub has occurred extensively in this area, with heavy reduction in productivity of both stock and crops. Aerial photographs show, over many hundreds of acres, traces of terraces constructed by the Soil Conservation Service during the 1930's. These terraces have been neglected by the peasant farming population and have inevitably been destroyed by further erosion. In recent years determined rehabilitation measures by the Department of Agriculture and the African Land Development Board have included the construction of many dams and of some hundreds of miles of new terraces. Farm planning and advice in this area have, however, been handicapped by lack of information about the fertility status, crop productivity and in particular the stock-carrying capacity of these eroded areas and of the cheapest and most effective methods of rehabilitation for high-density mixed farming.

The rainfall over the ten years of the experiment showed a mean annual value of 27 in. with a range from 10 in. to 53 in. The 59-year record at Machakos, some 16 miles away, is one of the longest in East Africa and has a mean value of 35.6 in. but with a standard deviation of 10 in. 6 per cent of years have less than 20 in. of rainfall while 30 per cent have less than 30 in. (Glover and Robinson, 1953).

ESTABLISHMENT STAGE

Thirty-two plots of one acre each, set out on the contour, were combined in four blocks as a 2^5 factorial trial of ploughing, ridging and cattle-manure treatments with two sown grasses and two planted grasses. All plots were split for a preliminary deep-ripping treatment.

Selection of Grasses

Both sown and planted grasses were tested. The most successful were *Cenchrus ciliaris* ("Ndata kivumbi" in the Kamba language) sown broadcast and Star grass (*Cynodon dactylon*) planted in scratch furrows on the contour. The Star grass gave high responses to dung and to fertilizers. While it will give high yields only on fairly fertile soils, it spreads rapidly to cover bare eroded surfaces and is valuable for checking erosion. *Eragrostis curvula* proved insufficiently drought-resistant. *Panicum coloratum* var. Makarikariensis was pruned into clumps by cattle leaving bare eroded soil between clumps and is not recommended. Trans Nzoia Rhodes grass (*Choloris* *gayana*) proved unexpectedly drought-resistant and productive for three years but then collapsed suddenly in a drought, to be replaced after some months by a fair population of self-sown seedlings. A more drought-resistant variety of Rhodes grass might well prove suitable, although unlikely to outyield the cenchrus. The latter occurs naturally in the ecological climax and is remarkably drought resistant under these conditions. Botanical analyses of all pastures by A. V. Bogdan are given in the paper by Pereira *et al.* (1959).

Cultivations

Deep ripping dried out the soil and retarded grass establishment and should not be used in basement complex soils in semi-arid conditions. Ploughing, ridging and cattle manure all improved grass establishment in two severe drought years. (10 in. in 1949 and 16 in. in 1950.) Cultivation, sowing and planting of grasses should replace the present "tumble-down fallow" on arable land following cereal crops. In this way rapid establishment of improved pastures can raise productivity. The badly eroded and over-grazed pasture however, when cleared of thorn-scrub, protected by fences and genuinely rested from grazing achieved an equally productive cover of indigenous grasses in three to four years. There is therefore little economic justification for breaking land especially for the establishment of pastures, unless land is so scarce that a rest period of this duration must be shortened. Regenerating bush was cut out by mattock. There is ample manpower available in this densely populated countryside, and no other form of bush control need be considered for this rather intensive agriculture.

PRODUCTION STAGE

Tests of Carrying Capacity

Sixteen half-acre paddocks of each of five types of pasture were compared. Half were put up for hay in each March-April rains and the hay fed in the following dry season. Doubts about soil fertility after erosion of topsoil were checked by a substantial annual dressing of two and half cwt. of mixed fertilizer (10 per cent N, 17 per cent P_2O_5, 11 per cent K_2O) on half of the plots.

Rotational grazing was on a flexible programme by which five separate groups each of 15 cattle grazed the five types of pasture, moving on when each paddock was grazed down, in an order determined by the grass available. Full records were maintained of the number of hours of grazing in each paddock. The cattle, which were uniform groups of adult small Zebu of about 500 lb. liveweight, were maintained in prime condition by the grazing; in the last three years of the experiment weighbridge facilities became available and confirmed that the cattle were gaining weight while grazing, although temporarily losing weight when stall-fed on hay during the dry season.

Overall carrying capacities were calculated for five pasture types and all treatments, on "grazing years" beginning on 1st November, e.g. the 12 months from 1st November, 1950, to 30th October, 1951, are shown against 1951. The annual rainfall in these periods proved to be substantially different from that calculated on calendar years. The results are summarized in Table I.

TABLE I.—CARRYING CAPACITY IN ACRES PER BEAST

(Mean of all pastures and treatments)

CALENDAR YEARS FROM 1ST JANUARY		GRAZING YEARS FROM 1ST NOVEMBER	
	Rainfall	Rainfall	Acres per Beast
	inches	*inches*	
1950 ..	16	—	—
1951 ..	53	42	1·7
1952 ..	22	32	1·0
1953 ..	21	15	1·7
1954 ..	24	31	1·7
1955 ..	27	22	3·4
1956 ..	23	24	3·1
1957 ..	44	39	1·9

From the large volume of data analysed in the full reports, the most important contrasts are those of the native grasses (untreated except by bush cutting, fencing and controlled grazing) compared with the successive agricultural improvements of ploughing, ridging, dunging, grass planting and sowing, fertilizer applications and haymaking.

Results for the five years 1953-57 in which the veld paddocks were grazed are given in Table II, for veld and for the three most successful grasses.

The lean year of 1955, in which the "long rains" of March/April/May amounted to only 4 in. and were followed by a drought of 100 days duration, is of special interest. In this severe drought, the pastures without fertilizers showed striking differences. The cenchrus was some 25 per cent better, and the Star grass nearly

25 per cent worse, than the natural veld. Fertilizers raised all the pastures to an approximately equal carrying capacity, and showed clearly that the nutrient status of this eroded soil was inadequate for full pasture development. The cenchrus appears better adapted to this low nutrient status, while the Star grass yields very poorly without fertilizers.

Haymaking proved somewhat unnecessary in the wettest years, while for two successive years, the March/April/May rains were so poor (4.35 in. in 1955 and 2.98 in. in 1956) that no hay was cut. In contrast 18.53 in. of rain fell in these three months in 1957 and an average of 1.17 tons of hay per acre was harvested. The hay crops from the Star grass and from the natural veld were both nearly doubled by fertilizers. Feeding of hay proved rather wasteful in practice. Termites destroyed part of the stacks, while rain penetrated half-used stacks and spoilt much hay, the total wastage being 23 per cent. The effect of hay-making on the annual yield was surprisingly small. Ignoring losses in stack, and assuming that all the hay harvested was fed in standard rations, the total keep was increased 10 per cent with Rhodes grass, was decreased 5 per cent with Star grass, and haymaking had negligible effects on the rest. Observation of the effects on the sward suggested that the tall hay stems shaded out the creeping grasses, so that after mowing soil cover was poorer. Haymaking does not therefore appear to offer a reliable method of increasing carrying capacity in this area, although in wet years, where grass yields far exceed stock requirements, the building of large well-thatched stacks on raised platforms which can be kept free of termites, provides sound insurance against future drought.

The effects of the initial cultivation treatments were still detectable after seven years, although their over-all effects on yields were negligible. Over the three years, 1953, 1954, 1955, the original cultivations, done in 1949, showed a 5 per cent yield increase from contour ploughing and a 7 per cent increase from ploughing followed by contour ridging. There was also a suggestion of a 2 per cent increase from the original small dressing of cattle dung. Contour ridging is therefore the most appropriate preparation for putting arable land down to grass in this area, while the use of cattle manure is clearly indicated by the fertilizer effects. The latter established the need to raise the nutrient status of the soil. It is not suggested that the use of fertilizers in this area will prove economic, but the need for careful use of dung and ash, and for intensified precautions against loss of topsoil, is emphasized.

Tests of Productivity under Arable Crops

The 40 paddocks ploughed up in 1956 for assessment of soil fertility showed no important differences in ease of breaking; even the tough tussocks of Makarikari Grass were readily turned in.

The arable yields were extremely variable but the plot size and replication proved adequate to obtain highly significant differences in each crop. Crops of beans alone, maize interplanted with beans and sorghum interplanted with beans, gave the following results. Firstly, there was no trace of residual effect of the different pasture types. Secondly, there was a very great response to the residuals of fertilizers applied in the pastures. The crop yields were approximately trebled in both 1956 and 1957 and in each crop the residual effects exceeded the effects of direct application of 1 cwt. of double superphosphate.

Without fertilizers, the total yields per acre on the broken pastures for the crop year November 1956 to October 1957 were 505 lb. of maize or 188 lb. of sorghum and 327 lb. of beans, under a rainfall of 24 in. during this twelve month period.

With fertilizer residuals this was raised to 1,460 lb. of maize or 544 lb. of sorghum and 731 lb. of beans. In spite of applications of

TABLE II.—CARRYING CAPACITY IN ACRES PER BEAST FOR "GRAZING YEARS"
(Beginning 1st November of Previous Year)

Grazing Year	Rainfall in.	NO FERTILIZER				WITH FERTILIZER			
		Veld	Rhodes	Cenchrus	Star	Veld	Rhodes	Cenchrus	Star
1953	15	2·0	1·7	1·7	1·7	2·0	1·5	1·5	1·5
1954	31	1·9	2·4	1·7	2·1	1·4	1·7	1·3	1·4
1955	22	4·8	4·3	3·6	5·9	3·1	3·1	3·3	3·2
1956	24	3·8	3·8	3·1	6·0	2·5	2·7	2·2	2·7
1957	39	2·4	2·3	1·9	2·7	1·5	1·8	1·4	1·3

DDT, some damage was suffered from termites, stalk borer and leaf-eating insects while the sorghum was also attacked by birds. All these hazards are characteristic of the locality, and must be considered when estimating productivity.

Comparison of values of crops and pastures

Compared with these yields and returns from cattle were somewhat meagre. Uniform healthy four to five year-old Zebu steers, whose average initial weight was 573 lb., gained an average of 81 lb. each in the 10 months from mid-June 1955 to mid-April 1956, replicate groups showing closely similar gains. The beasts lost an average of 40 lb. per head during the dry season, but regained this so rapidly when grazing improved that they fully regained the weights corresponding to steady progress at the initial rate. Thus the temporary set-back had no apparent effect on the season's progress. This is a well-known characteristic and serves as a valuable means of adjustment to the widely varying availability of food supplies. The liveweight gain averaged over all pastures and treatments, was 30 lb. per acre per year, an average daily gain of 0.27 lb. per beast. The yields of individual treatment combinations varied from 16 to 36 lb. per acre per year.

A subsequent group of ten Zebu steers of similar age, gained weight from 550 to 700 lb. in the 12 months November 1956 to November 1957, again losing weight during the dry season. The daily liveweight gain over the 12 months averaged over all pasture-types and treatments was 0.41 lb. per beast or 87 lb./acre/year, with a range from 55 lb./acre/year on the poorest to 114 lb./acre/year on the best pastures. The average liveweight yield represents about 48 lb. of beef per acre per year. Payne (1959) estimates the liveweight gains by Zebu beef cattle on several leading Kenya ranches as from 12 to 16 lb. of beef per acre per year, with average daily liveweight gains of between 0.6 and 0.7 lb. The heavy stocking rates on this experiment helped a little by conservation of hay in some years, this resulted in a substantially lower rate of liveweight increase per beast, but in a much higher yield per acre, as compared with large-scale commercial ranching. In these larger enterprises the lighter stocking rates are an essential precaution against drought.

The income from the first experimental group would have been about Sh. 38 per acre per annum, and from the second group about Sh. 60 per acre per year, or about one-third of the value of the crops. It is therefore important that the number of cattle kept should be limited to those required for milk and meat. Keeping of extra cattle for social reasons reduces the over-all productivity of the area.

SUMMARY AND CONCLUSIONS

This eroded and over-grazed land need not be broken to improve pasture; fencing, bush clearing and control of grazing produces equally good pastures but takes from one to two years longer than ley establishment.

Where land has been broken for cropping it should not be allowed to tumble back to weeds after a cropping sequence. Scratch ploughing on the contour and sowing with *Cenchrus ciliaris* will give substantial returns in grazing yield. Star grass is useful for erosion control rather than for yield unless the soil fertility can be raised by manure or fertilizers.

The nutrient status of these eroded, basement complex soils is below optimum for pasture yields; conservation of topsoil and the full use of cattle manure are both important.

Haymaking should be undertaken in good years as an insurance against extreme drought but is not a reliable routine method of raising carrying capacity in this erratic rainfall regime.

The cattle carrying capacity of the protected natural grasses without fertilizers varies from two to five acres per 500 lb. beast. With the usual feeding of crop residues, four acres per beast is a probable safe stocking rate for controlling grazing in this area.

The returns from arable are at present substantially greater than from stock.

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REFERENCES

H. C. Pereira and V. R. S. Beckley (1952), *Emp. J. exp. Agric., 21*, pp. 1–15.

J. Glover and P. Robinson (1953), *J. agric. Sci., 43*, p. 275.

H. C. Pereira, D. B. Thomas and P. H. Hosegood (1959), *Emp. J. exp. Agric.* (in the press).

W. J. A. Payne (1959), Animal Nutrition Division, E.A.A.F.R.O. Private Communication.

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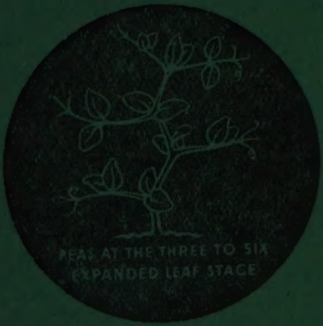

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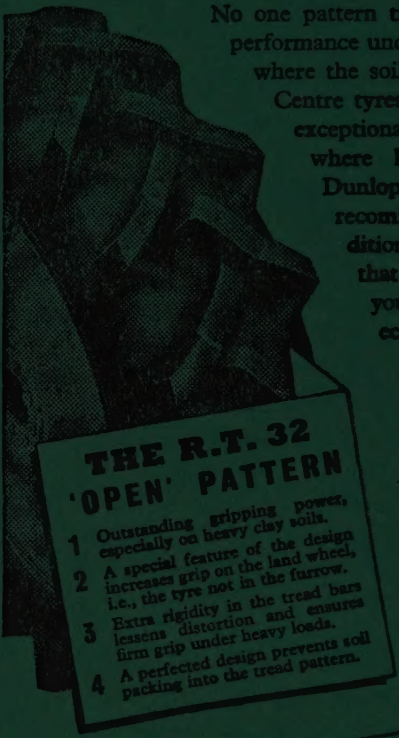

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